Heliyon 9 (2023) e13056

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Activities at risk of lead exposure and lead poisoning in children of travellers' families in charente, France

Stéphanie Vandentorren [a,f,*], Gilles Brabant [a,d], Lisbeth Spanjers [b], Stéphane Coudret [c], Sahar Haidar [a], Aude Mondeilh [d], Gaelle Gault [a], Marylène Comba [e], Anne Etchevers [a]

[a] *Santé Publique France, Paris, France*
[b] *Centre Social Le Chemin Du Hérisson, Terres-de-Haute-Charente, France*
[c] *Centre Social Les Alliers, Angoulême, France*
[d] *Fédération Nationale des Associations Solidaires D'action avec Les Tsiganes et Les Gens Du Voyage (FNASAT – Gens Du Voyage), Paris, France*
[e] *ARS - Délégation Départementale de La Charente, Angoulême, France*
[f] *University of Bordeaux; Bordeaux Population Health, Inserm U1219, Bordeaux, France*

A R T I C L E I N F O

Keywords:
Travellers
Lead poisoning
Environmental social health inequities
Childhood
Social structural health's determinants

A B S T R A C T

Background: –A study to assess lead exposure of traveller children aged from 9 months to 18 years old was conducted in Charente-France between 2017 and 2019.
Methods: A face-to-face questionnaire was administered to each participating family (N = 78). Blood samples were collected, and in case of lead poisoning, an environmental survey of soil, dust and water samples was also performed.
Results: –Among the 100 children, they were 39 girls and 61 boys. Among them, 40 suffered from lead poisoning (Blood Lead Level ≥50 μg/L). Being a boy aged between 11 and 14 years old, and participating in lead exposure at-risk activities were significantly associated with higher mean blood lead level.
Conclusion: –The high levels of lead detected advocate the reinforcement of lead poisoning screening for all children in the traveller population.

1. Introduction

Childhood lead poisoning - recognised as a public health issue since the 1980s - is a notifiable disease in France. The notification criterion is a first lifetime blood lead level measurement ≥50 μg/L in persons under 18 years old in France [1]. Screening for childhood lead poisoning targets persons in high-risk exposure contexts [2,3]. There are various risk factors for exposure including the presence of lead paint [4,5], degraded housing [6], living on a former industrial site [7], social precarity [8,9], renovation work in a child's home [8], fishing and hunting activities, and eating from dishes with lead varnish or using kohl [10,11]. Other factors such as recent immigration or belonging to the travelling community are also risk factors for lead exposure [12].

In France, the number of Travellers in the country is estimated at between 280,000 and 350,000. The term 'Travellers' is an administrative term for French citizens used in France since 1969 to designate both a socio-professional category, and a community of people whose way of life is characterized by regular or occasional nomadism. Travellers come from several ethnic groups. However, in

* Corresponding author.
E-mail address: Stephanie.VANDENTORREN@santepubliquefrance.fr (S. Vandentorren).

https://doi.org/10.1016/j.heliyon.2023.e13056
Received 9 September 2022; Received in revised form 13 January 2023; Accepted 13 January 2023
Available online 16 January 2023

the specific context of France, we distinguish them from Roma mainly by having the French nationality [13]. Because of their origins and their way of life, Travellers are victims of many prejudices and discrimination [14]. Living in caravans, poor hygienic conditions in encampments, together with proximity to traffic routes and to garbage dumps, are all living and environmental conditions that lead health indicators are less favourable than those of the general population [15]. Furthermore, certain scrap metal and metalworking activities result in lead and other heavy metal poisoning in Travellers [16].

Ironworking is yet another at-risk activity for lead exposure, as it produces lead dust that can contaminate children [12,17]. Work clothes and shoes brought back to the family home can be a source of lead exposure for them [18] and the presence of children in areas where there is scrap metal is a potential factor for lead contamination [19]. Several studies and lead-poisoning prevention actions have been conducted in traveller children [20,21]. Traveller, gypsy or roma children are considered at risk of lead poisoning in many countries as Spain [22,23], Kosovo [24] and France [25] because of their high and specific exposure to lead. They are exposed to lead through direct contact with contaminated soil and dust. Metal burning and scraping in the camps contaminate soil and spreads leaded dust. Since the 2000s, the metal recycling economy has become more industrial, negatively affecting the traditional trade of scrap metal often practised by the traveller population. This change has further marginalised this population, reinforcing their social exclusion [26–28]. In 2015, a case of lead poisoning (blood lead levels ≥50 μg/L) in a traveller child in the county of Charente was reported to the Regional Health Agency (ARS) of the Nouvelle Aquitaine region (south west of France) by local associations providing support to this population. The ARS subsequently launched a screening campaign, in accordance with the regulatory provisions (L 1334–1 to 6 of the CSP, circular DGS/DGUHC n "2002–285 of April 30, 2002) and the regularly updated recommendations of France's High Council for Public Health (HCSP) and in partnership with the same associations and the National Federation of Associations in Solidarity with Gypsies and Travellers (FNASAT), from March 01, 2017 to December 11, 2019, with a view to evaluating the number of cases of lead poisoning in traveller children living in Charente county. Besides this campaign, the ARS requested Santé publique France - the national public health agency - to conduct a statistical analysis to describe cases with diagnosed lead poisoning and to identify associated risk factors.

2. Methods

2.1. Population

The lead poisoning screening campaign implemented by the ARS targeted children aged from 9 months to 18 years old in the 750 traveller households residing in Charente county. According to an estimate made by the social centres (no census exists for this population), 975 children were eligible for the campaign. The target population, were the 78 families with children who frequented two traveller social centres in the two districts and accepted to fill in the questionnaire. The latter group (78 families) were living in 26 different sites: authorised halting sites, encampments on communal land or on family land, housing estates for travellers, individual houses sometimes hosting other families' caravans in their gardens, etc. All participating families were either directly engaged in an activity that could increase their risk of lead contamination, or lived in a place where other families were engaged in such activities.

2.2. Inclusion of children

The families who answered the study questionnaire and also accepted the blood test were included. Only children who were screened and whose family had completed the socio and life styles questionnaire were included in the analyses.

2.3. Collected data

2.3.1. Face-to-face questionnaire

The data were collected as part of the ARS screening campaign. Ethical approval was given by CNIL n°341194V42. Written informed consent was obtained from all participants for statistical analysis by Santé publique France. A face-to-face questionnaire was administered by trained social workers and collected information on the socio-demographic characteristics and living conditions of the families. It also included questions to identify potential lead exposure among the occupational activities of families. These activities are listed in France's High Council for Public Health (HCSP) screening guide [1] as follows: dismantling cars, recovering batteries, recovering car radiators, storing metals, cutting and handling scrap metal, burning materials to separate metals, stripping ironwork, scraping or sanding old paint, thermal stripping of old paint, and installing or removing lead structures in buildings. In addition, the questionnaire collected information on the proximity of these activities to the families' living areas, the frequency of the activities, and the measures taken by the families to limit lead contamination.

2.3.2. Blood lead measurements

Prescriptions for blood test were obtained from the screening campaign's reference physician or the Maternal and Child Protection (PMI) services network. Social workers accompanied families to a laboratory in the area. The blood sample could also be taken directly by the "Permanence d'Accès aux Soins de Santé" team at the referring hospital. Blood lead measurements were performed by the Eurofins-Biomnis and Cerba laboratories. The limits of quantification (LOQ) for blood lead analyses were equal to 10 μg/L for treated blood lead levels by Eurofins-Biomnis and 0.2 μg/L for Cerba. All measurements were above the LOQ.

2.3.3. Environmental measures

The environmental investigations around confirmed cases of lead poisoning, which were also implemented by the ARS, took place between July 2017 and January 2020. The teams comprised pairs including a technician from the ARS health-environment department and a social worker from the social centres participating. The environmental investigations concerned three halting sites, a camp on communal land, a camp on family land, a travellers' housing estate, and two individual houses with caravans in their gardens. All sites had a scrap metal and or burning site. At each of the three halting sites and camp, three composite soil samples were taken [29]: one from the scrap metal or burning area, a second from the children's play area, and a third near the caravans.

Loose soil samples (500 g) were taken to a maximum depth of 5 cm. Only one sample was collected from the gardens of individual houses or housing estates. A water sample was taken from the halting sites or camp and several dust samples were taken from inside and sometimes outside the caravans. Lead analyses in water, dust and soil were performed by accredited laboratories.

2.4. Statistics

Santé publique France statistical analyses were performed on anonymous data transmitted to the agency by the ARS. The distribution of blood lead levels was described in terms of percentiles and a geometric mean. The geometric means and their 95% confidence intervals were estimated according to the socio-demographic characteristics of the children and their proximity to at-risk activities. A generalised linear model was used to determine the risk factors associated with higher geometric mean blood lead levels. Variables were selected from bivariate analyses and adjusted for child age and gender. Statistical analyses were performed using R software (R Core Team, 2019).

2.5. Data protection

The analyses of ARS data by Santé publique France using anonymous data made available by the ARS were undertaken in a context of controlling an epidemiological situation. Data treatment was therefore performed in accordance with the provisions set out in French authorisation French National Confidentiality Committee no. 341194V42 regarding emergency investigations concerning exposure to an environmental risk.

3. Results

3.1. Description of the study population

From March 2017 to December 2019, among the 78 families who frequented the two social centres targeted by the ARS screening campaign and accepted to fill in the questionnaire, 43 agreed to participate in the screening campaign and 40 had at least one child with a blood lead measurement and a questionnaire. A total of 100 children were included in the analysis. The families included were composed of 1–5 children screened with a majority of siblings (75%) (Table 1).

Unlike included families, the non-included families (n = 35) were more likely to live in familial groups, (i.e., households located in the same place all or a part of the year and with family connections) (71.4% compared to 59.5%), and have fewer children (31.4% had three or more children compared to 53.5% for the included families). They were also more likely to live in urban areas (60.0% compared to 37.2%) and in caravans or mixed housing (i.e., house and caravan) (77.1% compared to 53.5%). Our sample of 100 children among the 40 families comprised 39 girls (39%) and 61 boys (61%). Median age was 8.7 years (standard deviation: 4.6 years); 41% were under 7 years old and 59% were between 7 and 18 years old.

3.2. Families' at-risk activities of lead exposure

At-risk activities were cited only by 20/43 families. The most frequently cited at-risk activities (Table 2) in the study questionnaire were burning materials to separate metals (75%), dismantling cars (75%), cutting and handling scrap metal (75%), storing metals (70%), collecting batteries (65%), and collecting car radiators (55%). Twenty percent (n = 9) of the families reported doing these

Table 1
Characteristics of the families included (n = 40) in the lead poisoning screening program in Charente, France 2017–2019.

Characteristics	n	%
Number of screened children		
1	10	25
2	12	30
3	8	20
4	8	20
5	2	5
At least one child with a blood lead level ≥ 25 μg/L	30	75
At least one child with a blood lead level ≥ 50 μg/L	24	60
At least two children with a blood lead level ≥ 50 μg/L	11	27.5

Table 2
Characteristics of at-risk activities carried out by families (n = 20) included in the lead poisoning screening program in Charente, France 2017–2019.

At-risk activity	n	%
Burning of materials to separate metals	15	75.0
Dismantling of cars	15	75.0
Cutting and handling of scrap metal	15	75.0
Metal storage	17	70.0
Battery recovery	13	65.0
Recovery of car radiators	10	50.0
Stripping of ironwork	8	40.0
Removal of old paint by scraping or sanding	4	20.0
Installation or removal of lead in buildings	2	10.0
Thermal stripping of old paint	1	5.0
Handling ammunition or fishing weights	18	41.9

activities several days a week. Among adults performing at-risk activities, 25% reported not changing their clothes after finishing the activity, 20% reported taking a shower, 55% reported washing their hands, and 35% reported using specific equipment for these activities. With regard to the location of these activities, all 20 families (100%) who declared at-risk activities stated that they practiced them in places close to where they lived, and 18 (90%) stated that these places were accessible to their children. Of the 20 families, 13 stated that at least one of their children was directly involved in these activities.

Forty-two percent of the families in our study sample handled ammunition or fishing weights.

3.3. Description of children's blood lead levels

The distribution of blood lead levels in the 100 children ranged from 5 to 332 μg/L (Fig. 1). Forty children had lead poisoning, defined as ≥50 μg/L (i.e., intervention level), of whom 13 had a level above 100 μg/L. Twenty-three had a level between 25 and 50 μg/L (i.e. above the vigilance level). The 50 and 95 percentiles were 37.5 μg/L and 140.4 μg/L, respectively. Out of the 40 children who had lead poisoning, 67.5% had a sibling with a blood lead level ≥50 μg/L (90% had a sibling with a blood lead level ≥25 μg/L). In children under 7 years old (n = 41), 36.6% had a blood lead level ≥50 μg/L and 34.1% between 25 and 50 μg/L. These proportions were 42.4% and 15.3%, respectively, in children over 7 years old.

The geometric mean of the blood lead levels of the children in the study sample was 34.8 μg/L (95% CI [28.9–41.9]) (Table 3). It was significantly higher in boys (45.4 μg/L 95% CI [36.0–57.2]) than in girls (23.0 μg/L 95% CI [17.4–30.3]) and higher in children

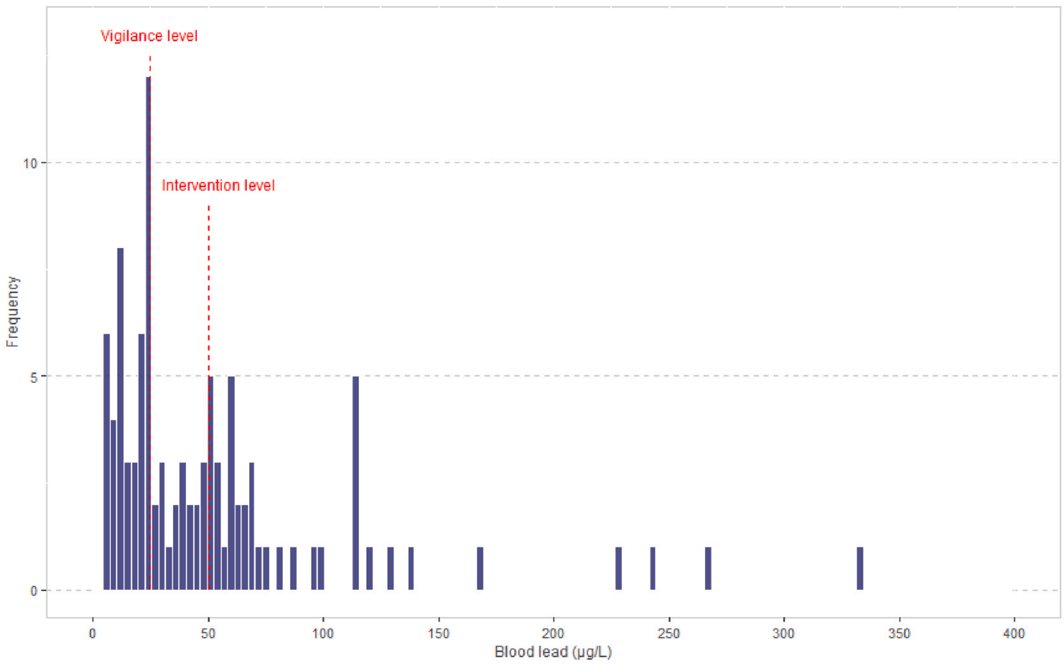

Fig. 1. Distribution of blood lead levels in Travellers children under 19 years old (n = 100), Charente 2017–2019. *The distribution of blood lead levels in the 100 children ranged from 5 to 332 μg/L. Forty children had lead poisoning, defined as ≥50 μg/L (i.e., intervention level), of whom 13 had a level above 100 μg/L. Twenty-three had a level between 25 (i.e. vigilance level) and 50 μg/L.

Table 3
Geometric blood lead levels in travellers children included in the lead poisoning screening program in Charente (n = 100), France 2017–2019.

Characteristics	n	Geometric mean (μg/L)	95% confidence interval
TOTAL	**100**	**34.8**	**28.9–41.9**
Gender			
Girl	39	23.0	17.4–30.3
Boy	61	45.4	36.0–57.2
Age (years)			
[0–5]	24	41.5	28.9–59.7
[6–10]	38	33.3	25.9–42.8
[11–14]	20	47.8	27.8–82.0
[15–17]	15	22.9	13.2–39.6
Familial group			
No	43	25.6	18.6–35.1
Yes	55	44.7	36.5–54.9
Type of housing			
Housing	42	24.6	17.8–34.0
Caravan or mixed (i.e., caravan + accommodation)	58	44.7	36.5–54.9
Place of residence			
Tenant, owner, lodger …	49	24.4	18.4–32.4
Halting site or parking area	51	49.0	39.6–60.5
Participate in at-risk activities			
No	67	29.8	23.6–37.7
Yes	33	47.5	35.3–64.0
Siblings with a blood lead level ≥ 50 μg/L			
No	62	26.8	21.2–33.9
Yes	38	53.3	40.9–69.6

Table 4
Geometric blood lead levels according at risk activities of lead exposure in travellers children included in the lead poisoning screening program in Charente (n = 100), France 2017–2019.

Activity at risk	n	Geometric mean (μg/L)	95% confidence interval
Handling of ammunition and fishing weights			
No	57	30.2	22.8–39.9
Yes	43	41.2	34.4–52.8
Burning of materials			
No	61	30.6	23.6–39.8
Yes	39	42.5	33.1–54.4
Dismantling of cars			
No	64	28.8	22.3–36.3
Yes	36	48.8	36.5–65.2
Scrap metal cutting			
No	66	32.4	25.4–41.4
Yes	34	39.8	29.9–53.0
Metal storage			
No	66	32.7	25.6–41.8
Yes	34	39.2	29.5–52.1
Recovery of batteries			
No	68	31.4	24.7–39.8
Yes	32	43.2	32.2–58.0
Recovery of radiators			
No	76	32.8	26.3–40.8
Yes	24	41.9	28.9–60.6
Iron pickling			
No	81	33.8	27.4–41.7
Yes	19	39.3	24.9–61.8
Paint stripping			
No	91	33.7	27.7–40.9
Yes	9	47.9	21.7–105.5
Installation of lead			
No	93	35.8	29.4–43.5
Yes	7	23.9	12.4–45.9
Thermal stripping			
No	98	35.3	29.2–42.7
Yes	2	<1.0	<1.0

aged 9 months to 5 years and 11–14 years than in the other age groups; however, this difference was not significant. Furthermore, the geometric mean of the blood lead levels was significantly higher in children living in caravans or mixed housing than in those living in sedentary housing (44.8 μg/L 95% CI [36.5–54.9] versus 24.6 μg/L 95% CI [17.8–34.0]), and in children living in a halting site or parking area than in those whose family rented or owned their housing, or who lived with a third party (48.7 μg/L 95% CI [39.1–60.7] versus 24.4 μg/L 95% CI [20.1–34.7]). Children living in a familial group had a significantly higher geometric mean blood lead level than those who did not (44.7 μg/L 95% CI [36.4–54.9] versus 25.6 μg/L 95% CI [18.6–35.1]).

The geometric mean of children aged 0–5 years in our study was more than 2.5 times higher than that of children aged 6 months to 6 years in the French population according to the Saturn-Inf study (14.9 μg/L (95% CI [14.5–15.4]) [30]. When compared to the geometric mean of the ESTEBAN 2014–2016 study [31], in 6–17 year olds in the general population (9.9 μg/L (95% CI [9.9–10.4]), this mean was more than 3.5 times higher. Also, unlike the ESTEBAN study, children aged 11–14 years in our study had higher lead levels (47.8 μg/L compared to 33.3 μg/L for 6–10 year olds, and 22.9 μg/L for 15–17 year olds).

Geometric mean blood lead level of children who were in contact with someone who carried out at-risk activities were all higher than those of children who were not (Table 4). The geometric mean was significantly higher only in children who were in contact with a person engaged in car dismantling compared to children not in contact with such a person (48.8 μg/L 95% CI [22.3–36.3] versus 28.8 μg/L 95% CI [36.5–65.2].

3.4. Multivariate analysis of factors associated with blood lead levels

Among the socio-demographic factors, boys had significantly higher blood lead levels than girls (27.4% higher CI 95% [13.7–41.1] with $p < 0.001$) (Table 5). Children whose families lived in a halting site or parking area had significantly higher blood lead levels than those of families that owned or rented their housing (20.9% higher CI 95% [6.2–35.5] with $p < 0.05$). Similarly, children who had a sibling with a blood lead 50 μg/L had higher blood lead levels (27.5% higher CI 95% [13.7–41.4] than others. Finally, children who participated in at-risk activities had significantly higher mean blood lead levels (14.4% higher CI 95% [0.3–28.5] with $p < 0.05$).

3.5. Sources of lead poisoning in children

Scraping metal or burning was systematically found in the living areas of diagnosed cases of lead poisoning (n = 40). As part of the environmental investigations, 14 soil samples were taken at eight different sites: five camps (collective living areas in the public domain with caravans (halting sites and parking), family sites)) and three house gardens (individual housing). For children living in houses, only one sample was taken from the garden. The concentrations in the garden soil samples were 42, 50 and 15,000 mg/kg. In terms of the halting sites and family sites, samples were taken from the scrap metal/burning area for five sites, from the living area for three sites and from the playground for two sites. Lead concentrations in soils ranged from 95 to 15,000 mg/kg. In the soils of family or communal campsites (n = 5), the average lead concentration in soil from playgrounds was lower (105 mg/kg) than that measured in the living areas (3422 mg/kg) and in the scrap metal areas (3244 mg/kg). The lead levels in the soil of the scrap metal or burning sites were systematically higher than 300 mg/kg, the threshold indicated by France's High Council for Public Health (HCSP) for possible lead poisoning [1]. This value was also exceeded at one of the three living areas sampled. However, none of the playground samples exceeded it. For dust samples taken from inside the home or caravans, results showed that only one in seven lead measurements in caravans and one out of two measurements in individual housing exceeded 70 μg/m2, which is the threshold value for recommending general screening [1]. Lead measurements in drinking water were all below the regulatory value of 10 μg/L. Environmental investigations also identified other possible sources of poisoning: handling or chewing of lead from hunting or fishing in two children, handling and burning of batteries in two children, and use of powdered kohl in one adolescent. The parents of three lead poisoning

Table 5
Risk factors of high blood lead levels in travellers children included in the lead poisoning screening program in Charente (n = 100), France 2017–2019.

Characteristics	Increase of geometric mean (%)	95% confidence interval	p-value
Gender			0.0001
Girl	Ref.		
Boy	27.4	13.7–41.1	
Age (per 2-year increase)	0.9	−2.1–3.9	0.5433
Familial group			0.1138
No	Ref.		
Yes	11.6	−2.8–26.1	
Place of residence			0.0057
Tenant, owner, lodger …	Ref.		
Halting site or parking area	20.9	6.2–35.5	
Participate in at-risk activities			0.0447
No	Ref.		
Yes	14.4	0.3–28.5	
Siblings with a blood lead level ≥ 50 μg/L			0.0001
No	Ref.		
Yes	27.5	13.7–41.4	

cases reported that their children were involved in scrap metal activities.

4. Discussion

Among the 750 families of the traveller population (including 975 children) residing in the two districts targeted by the study, 40 families participated in the screening campaign over the period 2017–2019. Of the 100 children who comprised out study sample, 40 had blood lead levels above the lead poisoning threshold of 50 μg/L, including 13 with levels above 100 μg/L. The prevalence of lead poisoning in 0–6 year olds was more than 26 times higher than that estimated in French population in the Saturn-Inf 2008–2009 survey (1.5%) [30]. This result was consistent with another study conducted in France between 2011 and 2013 in 65 children living in a scrap metal environment, 36 of whom had blood lead levels above the 100 μg/L threshold [32]. Being a boy, having siblings with blood lead level ≥50 μg/L and living in a halting site or parking area was associated with significantly higher blood lead levels (by 27.4%, 27.5% and 20.9% respectively). Furthermore, participating in high-risk activities, such as dismantling cars and burning materials to separate metals, was associated with a 14.4% higher blood lead level.

The environmental analyses indicated a high level of contamination (≥300 mg/kg threshold) in the soil samples taken from the one ironworking site involved, living areas in halting sites, and family or local council grounds. Measurements of indoor dust revealed quite low contamination of living areas (caravans and houses), probably due to the implementation of effective preventive actions such as health mediation work with promotion of hygiene measures (i.e remove shoes when entering the caravan, frequent wet cleaning of the accommodation to limit accumulation of lead dust, frequent hand washing …), provided by local associations to stop lead particles from passing from the ironwork site to the living area.

The practice of scrap metal working by traveller families is part of normal professional practice and generates an economy that is sometimes essential. Due to its nature, scrap recovery is often carried out on the fringes of the law, which makes the subject difficult to address. Children are particularly vulnerable to lead poisoning because of their immature and still developing nervous systems [33], high digestive absorption rates, their hand-to-mouth behaviors, and their proximity to the ground. Travelers are often victims of lead poisoning: they practice usually scrap metal activities and the vast majority of dwellings are located on the along roads with very heavy automobile traffic. The close proximity of ironwork sites to residential areas, such as halting sites and parking areas is an additional risk factor, as lead particles are carried by the wind, the dust and the fluidity of the soil [34]. Children can have access to ironworks site, often located on the camps and the teenagers can participate to scrap metal activities. The soil of the camps are contaminated by scrap metal. Leaded dust can be transferred into the caravans through work parents clothes or shoes. As a result children are chronically exposed to polluted soil. Moreover, Travelers's families residing in a caravan or mobile home do not have generally hot water, toilets or showers. Under these conditions, rigorous and systematic hygiene such as would make it necessary metal recovery activity could be an issue. The precariousness of housing, as well as that the small size of the caravans means that families are probably more exposed to all these lead pollution factors.

The limitations of our study include a lack of a sample design and a relatively small number of blood lead measurements (100/975 children). Furthermore, despite the fact that social workers conducted the study interviewees, it is possible that not all the participants provided complete details on their activities, for fear of being stigmatised or being subsequently forbidden to carry out scrap metal activities.

To conclude, our results suggest that all children of traveller families should be targeted for lead poisoning screening. Raising awareness among general practitioners and early child specialists (maternity and infant protection services (PMI in France), paediatricians, midwives, obstetricians, and even school doctors) can help target this population [35,36]. Moreover, it is important to limit the risks of contamination of living areas and playgrounds because of professional activities. Long-running health mediation work carried out on a daily basis by traveller associations could facilitate the implementation - in collaboration with travellers themselves - of preventive measures, awareness-raising activities on hygiene measures, and the wearing of appropriate equipment during scrap metal work, based on the solutions the families could find. Among these, the use by some travellers of geotextiles in scrap metal areas helps to protect the soil and contain dust, the manufacture of a small granular machine could be advantageously studied. Finally, a larger reflection on the recycling sector as a whole is needed, whereby public authorities together with the traveller community could envisage the substitution of the resale economy of materials for the monetization of a “zero kilometre” scrap collection service. In any case, involving travellers in all policymaking would be essential to ensure the effectiveness of such measures.

Conflicts of interest: None.

Funding: None.

Author contribution statement

Lisbeth Spanjers; Stéphane Coudret; Marylène Comba; Stéphanie Vandentorren: Conceived and designed the experiments; Performed the experiments.

Stéphanie Vandentorre; Gilles Brabant; Lisbeth Spanjers; Stéphane Coudret; Sahar Haidar; Aude Mondeilh; Gaelle Gault; Anne Etchevers: Analyzed and interpreted the data.

Lisbeth Spanjers; Stéphane Coudret; Gilles Brabant; Gaelle Gault; Anne Etchevers: Contributed reagents, materials, analysis tools or data.

Gilles Brabant; Lisbeth Spanjers; Stéphanie Vandentorren; Anne Etchevers; Sahar Haidar: Wrote the paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data included in article/supp. Material/referenced in article.

Declaration of interest's statement

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.

Acknowledgements

Eleonore Clarysse, Camille Roingeard, Sandrine Brisard, Stéphanie Raynaud, Stéphanie Balloux, Alexandra Bouchard, Séverine Chabeauti, Amélie Gonthier, Damien Pageaud, Frédérique Quirino Chaves, Gérard Houot, Laurent El Ghozi, Stéphane Lévêque, Erwan Autes, Alain Fontaine, Jean Claude Desenclos, Geneviève Chêne, Anne Laporte and Jude Sweeney.

References

[1] Haut Conseil de la santé publique, Détermination de nouveaux objectifs de gestion des expositions au plomb. Paris, 2014 accessed 30.05.22, http://www.hcsp.fr/explore.cgi/avisrapportsdomaine?clefr=444/.
[2] A. Etchevers, P. Glorennec, Y. Le Strat, C. Lecoffre, P. Bretin, A. Le Tertre, Screening for elevated blood lead levels in children: assessment of criteria and a proposal for new ones in France, Int. J. Environ. 12 (12) (2015) 15366–15378, https://doi.org/10.3390/ijerph121214989.
[3] Haut Conseil de la Santé Publique, Guide pratique de dépistage et de prise en charge des expositions au plomb chez l'enfant mineur et la femme enceinte, 2017 accessed 30.05.22, https://www.hcsp.fr/explore.cgi/avisrapportsdomaine?clefr=643/.
[4] B. Gulson, P. Anderson, A. Taylor, Surface dust wipes are the best predictors of blood lead in young children with elevated blood lead levels, Environ. Res. 126 (2013) 171–178, https://doi.org/10.1016/j.envres.2013.06.002.
[5] B.P. Lanphear, T.D. Matte, J. Rogers, R.P. Clickner, et al., The contribution of lead-contaminated house dust and residential soil to children's blood lead levels: a pooled analysis of 12 epidemiologic studies, Environ. Res. 79 (1998) 51–68, https://doi.org/10.1006/enrs.1998.3859.
[6] L. Ginot, C. Peyr, A. Fontaine, J. Cheymol, B. Buisson, G. Bellia, et al., Dépistage du saturnisme infantile à partir de la recherche de plomb dans l'habitat : une étude en région parisienne, Rev Epidém et Santé Publ. 43 (1995) 477–484, https://doi.org/10.1016/S0987-7983(05)80505-5.
[7] P. Glorennec, M. Ledrans, B. Fabres, Déclenchement d'un dépistage systématique du saturnisme infantile autour des sites industriels, Rev. Epidémiol. Santé Publique 54 (2) (2006) 117–125, https://doi.org/10.1016/S0398-7620(06)76705-0.
[8] A. Etchevers, A. Le Tertre, J.P. Lucas, P. Bretin, Y. Oulhote, B. Le Bot, P. Glorennec, Environmental determinants of different blood lead levels in children: a quantile analysis from a nationwide survey, Environ. Int. 74 (2015) 152–159, https://doi.org/10.1016/j.envint.2014.10.007.
[9] N. Krieger, J.T. Chen, P.D. Waterman, M.J. Soobader, S.V. Subramanian, Choosing area based socioeconomic measures to monitor social inequalities in low birth weight and childhood lead poisoning: the Public Health Disparities Geocoding Project (US), J. Epidemiol. Community Health 57 (2003) 186–199, https://doi.org/10.1136/jech.57.3.186.
[10] I. Nuwayhid, M. Nabulsi, S. Muwakkit, S. Kouzi, G. Salem, M. Mikati, M. Ariss, Blood lead concentrations in 1-3 year old Lebanese children: a cross-sectional study, Environ. Health 2 (2003) 5, https://doi.org/10.1186/1476-069x-2-5.
[11] C. Sainte, S. Gille, P. Montout, C. Droguet, A. Coursimault, B. Fargette, Utilisation des khôls traditionnels, une source sous-estimée de saturnisme infantile – analyse élémentaire de dix-huit khôls traditionnels par ICP-AES et spectrométrie de fluorescence X, Ann. Toxicol. Anal. 22 (4) (2011) 181–185, https://doi.org/10.1051/ata/2010029.
[12] P.J. Landrigan, E.L. Baker, Exposure of children in heavy metals from smelters: epidemiology and toxic consequences, Environ. Res. 25 (1) (1981) 204–224, https://doi.org/10.1016/0013-9351(81)90090-6. PMID: 7238464.
[13] Council of Europe, in: Glossaire terminologique raisonné du Conseil de l'Europe sur les questions roms -, 2012 [Internet]. [cited 2022 Dec 5]. Available from: http://a.cs.coe.int/team20/cahrom/documents/Glossaire%20Roms%20FR%20version%2018%20May%202012.pdf.
[14] E. Lynch, Travellers' tales, Nurs. Stand. (2006), https://doi.org/10.7748/ns.20.41.20.s28. PMID: 16827194.
[15] D. Vernon, The health of traveller-gypsies, Br. J. Nurs. 3 (18) (1994) 969–972.
[16] R. Torrents, M. Glaizal, C. Schmitt, N. Simon, L. de Haro, L'activité de ferraillage en habitat précaire : une nouvelle source de saturnisme infantile en métropole, Toxicol Anal Clin 26 (3) (2014) 172–175.
[17] B.P. Lanphear, P. Succop, S. Roda, G. Henningsen, The effect of soil abatement on blood lead levels in children living near a former smelting and milling operation, Publ. Health Rep. 118 (2) (2003) 83–91, https://doi.org/10.1093/phr/118.2.83.
[18] M. Redondo, F. Guisasola, An unknow risk group of lead poisoning: the gypsy children, Eur. J. Pediatr. 154 (3) (1995) 197–200, https://doi.org/10.1007/bf01954270.
[19] K. Hipkins, B. Materna, S. Payne, L. Kirsch, Family lead poisoning associated with occupational exposure, Clin. Pediatr. 43 (9) (2004) 845–849, https://doi.org/10.1177/000992280404300909.
[20] F. Pelissier, O. Guilbert, D. Mouly, C. Lecoffre, N. Franchitto, Dépistage du saturnisme chez les personnes mineures : exemple de la région Midi-Pyrénées de 2002 à 2013, Toxicol. Anal. et Clin. 27 (2) (2015) S62–S63, https://doi.org/10.1016/j.toxac.2015.03.099.
[21] G.M. Singal, et al., Blood lead, ethnic origin, and lead exposure, Arch. Dis. Child. 63 (1988) 973–975.
[22] M.J. Redondo Granado, A. Blanco Quiros, F.J. Alvarez Guisasola, Relationship between blood lead levels, Gypsy ethnia and other epidemiological factors, Anales Espanoles de Pediatria 42 (1) (1995) 22–26.
[23] J.M. Corretger, C. Fortuny, F. Botet, O. Valls, [Marginality, ethnic groups and health], An Esp Pediatr 36 (Suppl 48) (1992) 115–117.
[24] M.J. Brown, G. McWeeney, R. Kim, A. Tahirukaj, P. Bulat, S. Syla, et al., Lead poisoning among internally displaced roma, ashkali and Egyptian children in the united nations-administered province of Kosovo, Eur. J. Publ. Health 20 (3) (2010) 288–292.
[25] Réseau français des villes-santé de l'OMS, L'EXPOSITION PROFESSIONNELLE : SATURNISME, CANCERS, ACCIDENTS. La santé des gens du voyage – Comprendre et agir: RVSOMS, 2003, pp. 37–38.
[26] Association de Gestion du Schéma d'Accueil et d'Habitat des Gens du voyage du Puy de Dôme, L'inclusion sociale et professionnelle des Gens du voyage dans la filière du recyclage des métaux, 2018 accessed 30.05.22, http://www.agsgv63.com/.
[27] S. Hajioff, The health of the Roma people: a review of the published literature, J. Epidemiol. Community 54 (11) (2000) 864–869.
[28] A. Sutherland, Gypsies and health care, West. J. Med. 157 (3) (1992) 276–280.

[29] P. Bretin, Guide d'investigation environnementale des cas de saturnisme de l'enfant, Institut de Veille Sanitaire, Saint-Maurice, France, 2006.
[30] A. Etchevers, P. Bretin, C. Lecoffre, M. Bidondo, Y. Le Strat, P. Glorennec, et al., Blood lead levels and risk factors in young children in France, 2008–2009, Int. J. Hyg Environ. Health 217 (4–5) (2014) 528–537, https://doi.org/10.1016/j.ijheh.2013.10.002.
[31] A. Oleko, C. Fillol, A. Balicco, M.L. Bidondo, J. Gane, A. Saoudi, A. Zeghnoun, Imprégnation de la population française par le plomb. Programme national de biosurveillance, Esteban 2014-2016, Santé publique France, Saint-Maurice, 2020, p. 53, accessed 30.05.22, https://www.santepubliquefrance.fr/docs/impregnation-de-la-population-francaise-par-le-plomb.-programme-national-de-biosurveillance-esteban-2014-2016/.
[32] R. Torrents, M. Glaizal, C. Schmitt, N. Simon, L. de Haro, L'activité de ferraillage en habitat précaire : une nouvelle source de saturnisme infantile en métropole, Toxicol. Anal. et Clin. 26 (3) (2014) 172–175.
[33] R.L. Canfield, C.R. Henderson Jr., D.A. Cory-Slechta, C. Cox, T.A. Jusko, B.P. Lanphear, Intellectual impairment in children with blood lead concentrations below 10 microg per deciliter, N. Engl. J. Med. 348 (16) (2003) 1517–1526, https://doi.org/10.1056/NEJMoa022848.
[34] H. Mielke, P. Reagan, Soil is an important pathway of human lead exposure, Environ. Health Perspect. 106 (1998) 217, https://doi.org/10.2307/3433922.
[35] V.R. Cabedo García, E. Ortells i Ros, L. Baquero Toledo, N. Bosch Girona, A. Montero Royo, A. Nácher Fernández, et al., Cómo son y de qué padecen los gitanos, Atención Primaria 26 (1) (2000) 21–25, https://doi.org/10.1016/s0212-6567(00)78600-8.
[36] M. McKee, The health of gypsies, BMJ 315 (7117) (1997) 1172–1173, https://doi.org/10.1136/bmj.315.7117.1172.