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ORIGINAL ARTICLE

Health status of Italian children living close to cultivations sprayed with pesticides

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SUMMARY

BACKGROUND: Pesticides are used to control pests, but they are toxic and may severely harm children's health. We assessed health outcomes in Italian children living close to cultivations sprayed with pesticides.

METHODS: In 2011–2012, 2,367 schoolchildren (6–14 years) living in eight Italian cities participated in the Indoor-School observational study. Parents filled in a standardised questionnaire on children's health and related risk factors. Children were classified as exposed to pesticides if living close to cultivations sprayed with pesticides. The association between the last three months of respiratory, allergic or systemic symptoms and pesticide exposure was assessed by multinomial logistic regression models, accounting for host/environmental risk factors.

RESULTS: Overall, 14% of children were exposed to pesticides, with significant differences among geographical areas: 21.2% in Northern Italy, 11.6% in Central Italy, and 9.7% in Southern Italy. Pesticide exposure was significantly associated with having: 1) 'often': eye symptoms (OR 3.81, 95% CI 2.06–7.05), skin symptoms (OR 2.60, 95% CI 1.34–5.03), lower airway symptoms (OR 2.38, 95% CI 1.41–4.01), systemic symptoms (OR 1.56, 95% CI 0.96–2.53, borderline); 2) 'daily': upper airways symptoms (OR 2.25, 95% CI 1.25–4.07) and systemic symptoms (OR 2.76, 95% CI 1.43–5.34).

CONCLUSIONS: Self-reported pesticide exposure was associated with respiratory, allergic or systemic symptoms in children. Public authorities should be aware of and intervene to mitigate this health risk.

KEY WORDS: respiratory symptoms; allergic symptoms; systemic symptoms; observational study; schoolchildren

Pesticides are chemical compounds that kill pests, including insects, rodents, fungi, and unwanted plants.[1] Pesticides for plant protection include herbicides, fungicides, insecticides, acaricides, plant growth regulators, and repellents.[2] At the global level, despite a recently reached plateau, total pesticide use increased by nearly 50% in the last decade compared to the 1990s. Over the past three decades, yearly pesticide use averaged 1.58 kg/hectare (kg/ha), 0.37 kg/person (kg/cap), and 0.79 kg/thousand international dollars (kg/1,000 Int$) of agricultural production (according to the World Bank, an international dollar would buy in the cited country a comparable amount of goods and services a US dollar would buy in the United States).[3] In 2020, Italy ranked among the world's top 10 countries for pesticide applications in agriculture with 57 kilotonnes (kt);[4] Italian use per cropland area, per capita and per value of agricultural production were 6.01 kg/ha, 0.95 kg/cap, and 1.44 kg/1,000 Int$, respectively.[5]

Links have been found between pesticide exposure (through ingestion, inhalation, and skin contact) and an increased risk of several chronic diseases, including various types of cancers; neurological disorders such as Parkinson's and Alzheimer's diseases; cardiovascular diseases; developmental delays in children; effects on reproductive capacity and infertility; cognitive impairments; and impaired respiratory health.[6]

Workers who apply pesticides, such as agricultural workers, and people in the immediate area when pesticides are used, like those living near cultivations sprayed with pesticides, are at higher risk of adverse health effects.[1]

The association between pesticide exposure and asthma is more evident and consistent in children than adults regarding impaired respiratory health.[7] When post-natal pesticide exposure of children was assessed through a parental questionnaire, an association with respiratory symptoms was found.[8] Recent reviews reported pesticide exposure was associated with children's respiratory and allergic effects such as asthma, wheezing, cough, acute respiratory infections, hay fever, rhinitis, eczema, chronic phlegm, and lung function impairments.[9,10] The most frequently studied health outcomes were acute respiratory symptoms, followed by asthma and lung function measurements.[11]

In this framework, within the 'Exposure to Indoor Pollutants: Guidelines for Assessing Risk Factors in the School Environment and Defining Measures to Protect

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Respiratory Health of Schoolchildren and Adolescents (Indoor-School)' Project, funded by the Centre for Disease Control (CCM) of the Italian Ministry of Health,[12] we assessed the possible associations between respiratory, allergic, and systemic symptoms and living close to cultivations sprayed with pesticides in Italian schoolchildren.

METHODS

Study population and materials

Indoor-School is an observational study conducted in 53 schools in eight Italian cities (Udine, Milan, Sondrio, Pisa, Rome, Bari, Palermo, Cagliari). From November 2011 to June 2012, 2,367 schoolchildren (6–14 years) participated in the first baseline survey of the study.

Parents filled in a standardised questionnaire on children's health and dietary intake, home risk factors (e.g. parents' smoking habits, pet keeping, presence of moulds/dampness, cooking/heating systems, gas appliances, cleaning products, etc.), and family history of any respiratory/allergic diseases. The questionnaire was derived from previous questionnaires used in studies conducted among schoolchildren in Europe: 'International Study of Asthma and Allergies in Childhood' (ISAAC) project,[13] 'Health Effects of School Environment' (HESE) study,[14] 'School Environment and Respiratory Health of Children' (SEARCH) study[15] and 'Schools Indoor Pollution and Health Observatory Network in Europe' (SINPHONIE) study.[16]

Symptoms were assessed through the question, 'During the past 3 months, has your child had any of the following symptoms?' with four possible answers (never, 1–3 times per month, 1–4 times per week and daily) to a list of different symptoms. Each of the five symptom categories (upper airways, lower airways, eye-related, skin-related, and systemic symptoms) was defined by the presence of at least one of the symptoms listed in Supplementary Table S1 for such category.

Pesticide exposure was assessed through the question, 'Is the house close to cultivations (kitchen gardens, orchards, vineyards) that are sprayed with pesticides?' with two possible answers (yes and no).

The Indoor-School study protocol, participant information sheet, and consent form were locally approved by the Ethics Committee of each participating centre after the approval obtained by the study's Clinical Manager from the Ethics Committee of the University Hospital 'P. Giaccone' of Palermo, Italy (N. 5/2011, 18/5/2011).

Statistical analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS v28.0; IBM Corporation, Armonk, New York, USA). The routines used were frequency distributions, χ^2 tests, and multinomial logistic regression analyses. The significance level was set at 0.05.

The association between respiratory (upper and lower airways symptoms), allergic (eye and skin-related symptoms), systemic symptoms, and living close to cultivations sprayed with pesticides were assessed by multinomial logistic regression models (reference category = never symptoms) accounting for the effect of age, sex, body mass index (BMI), family history of asthma/rhinitis, secondhand smoke (SHS) at home, mould exposure at home, traffic near the dwelling and geographical area.

RESULTS

The study included 2,367 children: the mean age was 10.3 years for males and 10.2 years for females. Characteristics and risk factors of children by sex are reported in Table 1. Males, compared to females, had a significantly higher BMI (19.1 ± 3.7 vs 18.6 ± 3.3), a higher rate of employed fathers (fully employed: 87.6% vs 87.6%; part-time employed: 8.0% vs 5.7%) and a less frequent family history of asthma/rhinitis (35.5% vs 39.9%). Borderline significant associations were observed for SHS and mould exposure at home: males had a higher frequency of exposure to both SHS (23.0%, in females, this was 20.1%) and mould (20.2%, in females 17.5%).

Overall, 14% of children lived close to cultivations sprayed with pesticides. Pesticide exposure was significantly different among geographical areas, with a North-South gradient of 21.2% in Northern Italy (Udine, Milan, and Sondrio), 11.6% in Central Italy (Pisa and Rome) and 9.7% in Southern Italy (Cagliari, Bari, and Palermo) (Supplementary Figure S1).

Supplementary Table S2 reports the prevalence rates of respiratory/allergic/systemic symptoms by geographical area: The prevalence rates of respiratory and systemic symptoms were significantly higher in schoolchildren living in Southern Italy than in Northern and Central Italy (Supplementary Table S2).

Table 2 describes the results of the multinomial logistic regression analyses for the associations between respiratory/allergic/systemic symptoms and living close to cultivations sprayed with pesticides ('never symptoms' reference category vs 'daily', 'often (1–4 times/week)', 'sometimes (1–3 times/month)'). Living close to cultivations sprayed with pesticides was significantly associated with having, 'often', eye symptoms (odds ratio [OR] 3.81, 95% confidence interval [CI] 2.06–7.05), skin symptoms (OR 2.60, 95% CI 1.34–5.03), lower airway symptoms (OR 2.38, 95% CI 1.41–4.01), systemic symptoms (OR 1.56, 95% CI 0.96–2.53, borderline) and, 'daily', upper airways symptoms (OR 2.25, 95% CI 1.25–4.07), and systemic symptoms (OR 2.76, 95% CI 1.43–5.34) (Table 2).

Table 1. Characteristics and risk factors of children according to sex.

	Male *n/N* (%)	Female *n/N* (%)	Total *n/N* (%)	*P*-value
Age, years	(*N* = 1,198)	(*N* = 1,169)	(*N* = 2,367)	
Mean ± SD	10.3 ± 1.8	10.2 ± 1.8	10.2 ± 1.8	0.198
Body mass index, kg/m^2	(*N* = 1,016)	(*N* = 1,023)	(*N* = 2,039)	
Mean ± SD	19.1 ± 3.7†	18.6 ± 3.3†	18.9 ± 3.5†	0.002†
Mother's education	(*N* = 1,153)	(*N* = 1,144)	(*N* = 2,297)	0.484
None/elementary school	56/1,153 (4.9)	41/1,144 (3.6)	97/2,297 (4.2)	
Middle school	271/1,153 (23.5)	278/1,144 (24.3)	549/2,297 (23.9)	
High school	553/1,153 (48.0)	547/1,144 (47.7)	1,100/2,297 (47.9)	
University	273/1,153 (23.6)	278/1,144 (24.4)	551/2,297 (24.0)	
Father's education	(*N* = 1,135)	(*N* = 1,120)	(*N* = 2,255)	0.731
None/elementary school	37/1,135 (3.3)	40/1,120 (3.6)	77/2,255 (3.4)	
Middle school	347/1,135 (30.5)	331/1,120 (29.6)	678/2,255 (30.1)	
High school	488/1,135 (43.0)	504/1,120 (45.0)	992/2,255 (44.0)	
University	263/1,135 (23.2)	245/1,120 (21.8)	508/2,255 (22.5)	
Mother's employment	(*N* = 1,139)	(*N* = 1,125)	(*N* = 2,264)	0.635
Fully employed	403/1,139 (35.4)	429/1,125 (38.1)	832/2,264 (36.7)	
Part-time employed	359/1,139 (31.4)	336/1,125 (29.9)	695/2,264 (30.7)	
Unemployed	369/1,139 (32.4)	349/1,125 (31.1)	718/2,264 (31.8)	
Pensioner	4/1,139 (0.4)	5/1,125 (0.4)	9/2,264 (0.4)	
Disabled	4/1,139 (0.4)	6/1,125 (0.5)	10/2,264 (0.4)	
Father's employment	(*N* = 1,125)	(*N* = 1,104)	(*N* = 2,229)	0.047†
Fully employed	985/1,125 (87.6)†	967/1,104 (87.6)†	1,952/2,229 (87.6)†	
Part-time employed	90/1,125 (8.0)†	63/1,104 (5.7)†	153/2,229 (6.9)†	
Unemployed	33/1,125 (2.8)†	47/1,104 (4.3)†	80/2,229 (3.6)†	
Pensioner	13/1,125 (1.2)†	19/1,104 (1.7)†	32/2,229 (1.4)†	
Disabled	4/1,125 (0.4)†	8/1,104 (0.7)†	12/2,229 (0.5)†	
Family history of asthma/rhinitis	(*N* = 1,200)	(*N* = 1,169)	(*N* = 2,369)	
	426/1,200 (35.5)†	466/1,169 (39.9)†	892/2,369 (37.7)†	0.028†
Secondhand smoke at home	(*N* = 1,172)	(*N* = 1,138)	(*N* = 2,310)	
	269/1,172 (23.0)‡	229/1,138 (20.1)‡	498/2,310 (21.6)‡	0.098‡
Mould exposure at home	(*N* = 1,141)	(*N* = 1,108)	(*N*= 2,249)	
	231/1,141 (20.2)‡	194/1,108 (17.5)‡	425/2,249 (18.9)‡	0.097‡
Cat/dog at home	(*N* = 1,112)	(*N* = 1,048)	(*N* = 2,160)	
	336/1,112 (30.2)	319/1,048 (30.4)	655/2,160 (30.3)	0.910
Traffic intensity near home	(*N* = 1,150)	(*N* = 1,138)	(*N* = 2,288)	0.450
None-little	176/1,150 (15.3)	193/1,138 (17.0)	369/2,288 (16.1)	
Moderate	599/1,150 (52.1)	595/1,138 (52.3)	1,194/2,288 (52.2)	
Heavy	375/1,150 (32.6)	350/1,138 (30.7)	725/2,288 (31.7)	
Geographical area	(*N* = 1,200)	(*N* = 1,169)	(*N* = 2,369)	0.438
Northern Italy	403/1,200 (33.6)	364/1,169 (31.1)	767/2,369 (32.4)	
Central Italy	370/1,200 (30.8)	370/1,169 (31.7)	740/2,369 (31.2)	
Southern Italy	427/1,200 (35.6)	435/1,169 (37.2)	862/2,369 (36.4)	

† Statistically significant values.
‡ Borderline values.
SD = standard deviation.

DISCUSSION

We have found health risks for children living in the proximity of cultivations (kitchen gardens, orchards, vineyards) sprayed with pesticides. Since personal exposure can be influenced by many different factors related to each subject's lifestyle, personal habits, and exposure to other air pollution sources, we included in our analyses the effects of confounding factors such as age, sex, BMI, family history of asthma/rhinitis, SHS at home, mould exposure at home, traffic near the dwelling and geographical area.

After adjustment for such potential confounders, schoolchildren living close to cultivations sprayed with pesticides had higher risks of 'often' reporting eye symptoms, skin symptoms, lower airway symptoms, and systemic symptoms, as well as higher risks of 'daily' reporting upper airways symptoms and systemic symptoms.

Our results are generally consistent with those recently reported by other authors, who have analysed the effects of pesticide exposure on respiratory/allergic/systemic health status in children. Possible links between a biomarker of pesticide exposure and asthma and rhinitis are suggested by a study on schoolchildren living in a French vineyard rural area.[17] The use of pesticides at home was significantly associated with wheezing in 1,203 Lebanese schoolchildren.[18] Among 5-year-old children living within 5 km of banana plantations in Matina County (Costa Rica), current pyrethroid (insecticides) and current mancozeb (pesticide) exposures were associated with wheeze, itchy rash, doctor-diagnosed asthma and lower respiratory tract infections (LRTI).[19] A study on 1,001 schoolchildren from three agricultural areas of South Africa showed that headache severity score was consistently increased in relation to pesticide-related farm activities; in

Table 2. Association between respiratory/allergic/systemic symptoms and living close to cultivations sprayed with pesticides.*

	OR	95% CI	*P*-value
Eye symptoms			
Daily	1.87	0.65–5.38	0.248
Often (1–4 times/week)	3.81†	2.06–7.05†	<0.001†
Sometimes (1–3 times/month)	1.08	0.74–1.56	0.701
Skin-related symptoms			
Daily	1.45	0.69–3.08	0.329
Often (1–4 times/week)	2.60†	1.34–5.03†	0.005†
Sometimes (1–3 times/month)	1.24	0.84–1.84	0.283
Upper airway symptoms			
Daily	2.25†	1.25–4.07†	0.007†
Often (1–4 times/week)	1.34	0.82–2.19	0.241
Sometimes (1–3 times/month)	0.95	0.70–1.30	0.767
Lower airway symptoms			
Daily	1.79	0.81–3.96	0.153
Often (1–4 times/week)	2.38†	1.41–4.01†	0.001†
Sometimes (1–3 times/month)	0.97	0.72–1.31	0.837
Systemic symptoms			
Daily	2.76†	1.43–5.34†	0.003†
Often (1–4 times/week)	1.56‡	0.96–2.53‡	0.070‡
Sometimes (1–3 times/month)	1.24	0.86–1.78	0.251

* A multinomial logistic regression model for each symptom category was adjusted for age, sex, BMI, family history of asthma/rhinitis, SHS at home, mould exposure at home, traffic near the dwelling and geographical area. Reference category: 'never symptoms'.
† Statistically significant values on multinomial logistic regression models.
‡ Borderline values.
OR = odds ratio; CI = confidence interval; BMI = body mass index; SHS = secondhand smoke.

addition, there was a significant exposure-response relationship between headache score and gradient of exposure to seeing and smelling pesticide spray.[20]

In our study, symptoms were categorised into five groups, as Baloch and colleagues did in their paper, within the framework of the European SINPHONIE (Schools Indoor Pollution and Health Observatory Network in Europe) Study, on the relationship between indoor air quality and comfort conditions in classrooms and health among European schoolchildren.[21] Our results show that Italian schoolchildren had a higher prevalence of daily/often (1–4 times/week) eye (4.6% vs 3.1%), skin (6.0% vs 5.1%), upper respiratory (13.5% vs 10.8%), lower respiratory (8.7% vs 7.9%) and systemic (16.9% vs 11.8%) symptoms than European schoolchildren. This comparison can only be made with Baloch's paper because the same questions and the same categorisation of health outcomes were used in both studies.

In addition, respiratory and systemic symptoms were more frequently reported in schoolchildren living in Southern Italy than in Northern/Central Italy, despite being less exposed with respect to the other two geographical areas. This might be due to the type and amount of pesticides used and how often they are used. Characteristics of agricultural pesticides determine the mode of exposure (oral, dermal, ingestion, inhalation, and all routes) and the effects on health.[22]

A limitation of our study may be using a proxy to define exposure to pesticides, such as the children's residence proximity to cultivations sprayed with pesticides. The possibility of georeferencing the participants' homes and cultivated fields would have improved the precision of the exposure estimate, but the study protocol did not include the obligation to know the participants' residential addresses nor the use of the data from the Coordination of Information on the Environment (CORINE) programme to find information on the type and extent of agricultural surfaces. Nevertheless, spatial indicators, including residential proximity to fields, were identified as determinants of pesticide exposure in a recently published review, including several original studies.[23] It should be noted that a strong relationship between the proximity of the home to pesticide-treated farmland/orchard and pesticide concentration measured in dust samples has been shown by many studies.[24–27]

Another limitation of our study may be using a questionnaire to collect data on respiratory symptoms/diseases, potentially affected by a reporting bias, as it relies upon individual beliefs and risk perception. Nevertheless, the standardised questionnaire is one of the main investigation tools in respiratory epidemiology,[28] and the questions used were derived from validated international questionnaires.

The main strengths of our study were the large and widespread sample, which was representative of the country's situation, the standard protocols, and the numerous multifaceted aspects collected using the questionnaire. Concerning possible prevention, international conventions provide tools for countries to protect their populations from exposure to toxic pesticides. Successful implementation of these conventions requires information about the incidence and circumstances of pesticide exposure and the health impact of exposure.[1] The International Code of Conduct on Pesticide Management, drawn up by the Food and Agriculture Organization of the United

Nations (FAO) and the WHO, provides voluntary standards of conduct for all entities engaged in or associated with the management of pesticides throughout their life cycle, from production to disposal. The main objective of the Code of Conduct is to maximise the benefits of pesticide use to effectively control pests in public health and agriculture while protecting human and animal health and the environment from their harmful effects.[29]

CONCLUSIONS

Our study points out that self-reported exposure to pesticides used in cultivations near home is associated with respiratory/allergic/systemic symptoms in Italian schoolchildren. Further studies evaluating both the type and quantity of sprayed pesticides and their use near residential areas, as well as the interaction with air, water, and soil pollution, should be conducted to clarify the underlying mechanisms of the adverse respiratory/allergic/systemic impacts, especially in more susceptible population groups (children and elderly). Public authorities should be aware of and intervene to mitigate this risk factor to protect human health, especially of children, and the ecosystem. Indeed, it is important to restrict or ban pesticide use in public spaces, areas used for drinking water extraction, and, where possible, ecologically sensitive areas.[6]

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RÉSUMÉ

CONTEXTE: Nous avons examiné les conséquences sur la santé des enfants italiens résidant près de champs traités avec des pesticides, qui sont employés pour combattre les parasites malgré leur caractère toxique et leur potentiel danger pour la santé des plus jeunes.

MÉTHODES: En 2011–2012, une étude d'observation appelée Indoor-School a été menée auprès de 2,367 écoliers âgés de 6 à 14 ans vivant dans huit villes italiennes. Les parents ont répondu à un questionnaire standardisé concernant la santé de leurs enfants et les facteurs de risque associés. Les enfants ont été considérés comme exposés aux pesticides s'ils résidaient à proximité de cultures traitées avec ces produits chimiques. L'association entre les symptômes respiratoires, allergiques ou systémiques des trois derniers mois et l'exposition aux pesticides a été analysée à l'aide de modèles de régression logistique multinomiale, en prenant en compte les facteurs de risque liés à l'hôte et à l'environnement.

RÉSULTATS: Dans l'ensemble, 14% des enfants ont été exposés aux pesticides, avec des variations significatives entre les différentes régions géographiques : 21,2% dans le Nord de l'Italie, 11,6% dans le Centre de l'Italie et 9,7% dans le Sud de l'Italie. L'exposition aux pesticides était significativement liée à la présence : 1) « souvent » : de symptômes oculaires (OR 3,81 ; IC à 95% 2,06–7,05), de symptômes cutanés (OR 2,60 ; IC à 95% 1,34–5,03), de symptômes des voies respiratoires inférieures (OR 2,38 ; IC à 95% 1,41–4,01), de symptômes systémiques (OR 1,56 ; IC à 95% 0,96–2,53 ; limite) ; 2) « quotidiennement » : de symptômes des voies respiratoires supérieures (OR 2,25 ; IC à 95% 1,25–4,07) et de symptômes systémiques (OR 2,76 ; IC à 95% 1,43–5,34).

CONCLUSIONS: L'exposition aux pesticides a été associée à des symptômes respiratoires, allergiques ou systémiques chez les enfants. Les autorités publiques devraient être conscientes de ce risque sanitaire et intervenir pour l'atténuer.