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Indoor air pollution: an Italian Knowledge, Attitude and Practice (KAP) study among the general population

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Parole chiave: Inquinamento indoor; KAP study; studio cross-sectional; conoscenza; atteggiamenti; comportamenti

Abstract

Background. *Indoor air pollution negatively affects population health and the national health services in terms of socio-economic costs. The presence of indoor pollutants depends a lot on lifestyles.*
Study design. *The aim of this work is to evaluate knowledge, daily habits and the preventive behaviors in order to contrast the effects on health caused by indoor pollutants.*
Methods. *The study was conducted through the administration of questionnaires to the population resident in the metropolitan city of Messina (Italy), asking about sociodemographic characteristics, knowledge, daily habits and preventive behaviors.*
Results. *The questionnaire was filled by 894 subjects (46.8% M; 53.2% F). Regarding knowledge, 66.8% had heard of indoor air pollution and 94.9% knew what the most common indoor pollutants are; regarding daily habits they often aired out the house (91.9% in the morning and 71.4% after cleaning), 24.8% were smokers and 36.7 of them smoked indoors; regarding preventive behaviors, 41.6% chose the cleaning products based on habit and only 32.9% bought plants able to purify environments.*
Conclusions. *Although the analyzed population had adequate knowledge of indoor air pollution, this did not strongly impact on the adoption of healthy lifestyles. Therefore, it becomes necessary to intervene on a social level with environmental education activities, starting from school age.*

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Introduction

Indoor air pollution, defined by the Italian Ministry of Health as "the modification of the normal composition or physical state of indoor atmospheric air, due to the presence in the same of one or more substances in concentrations and with characteristics able to alter the normal environmental conditions and healthiness of the air itself and able to constitute a danger or a direct or indirect damage to human health" (1), is an important determinant of health because it not only negatively affects population health and productivity (2), but also affects the community and the national health services in terms of high social, health (3) and economic (4) costs.

The majority of urban residents spend the majority of their waking hours indoors (5), staying less than one hour outside each day. People who live in urban centers spend, on average, 95–97% of their time in private and public enclosed places (more than 20 hours per day, of which almost half are spent at home), and only 1% of their time outside (6-8).

As well as outdoor atmospheric air pollution has received considerable attention for many years and whose causes, health effects, and preventative measures have quickly been identified (9), recently the same attention has been given to indoor pollution (10). Indeed, numerous scientific evidence demonstrates that indoor air pollution can represent an important cofactor in the genesis of cardiovascular diseases (11-12), and other systemic diseases (13-14) and some indoor pollutants can contribute to the aggravation of pre-existing pathologies (15). In addition, we have to consider that even low levels of pollution might have an adverse long-term impact on health (16-18).

These pathologies can affect any individual in any age group, but what is certain is that there are some subjects who are more susceptible than others, these are defined as "groups most at risk", which include: children (19-20), elderly people, subjects with chronic pathologies (respiratory and/or heart diseases) (21-22), subjects suffering from immune diseases and subjects with low income (23).

The substances capable of altering the quality of indoor air can be classified as chemical, physical and biological agents; they partly come from outside (outdoor air pollution, pollen), but many are produced from internal sources. The main internal sources of pollution are represented by occupants (humans, animals), dust, structures, building materials, furnishings, systems (air conditioners, humidifiers, plumbing systems) (24).

The presence of indoor pollutants depends a lot on our lifestyles and choices (25-26). There are several attitudes and behaviors that can contribute to indoor air pollution: smoking, poor ventilation, use of chemical cleaners, cooking without adequate ventilation, using air fresheners, using insecticides indoors, neglecting regular cleaning.

Smoking indoors releases several chemicals into the air, such as carbon monoxide, formaldehyde, and benzene (27). These chemicals are harmful to both smokers and non-smokers alike.

Insufficient fresh air circulation in indoor spaces can lead to an accumulation of pollutants. This can happen in poorly ventilated areas or when windows are rarely opened (28).

Many household cleaning products contain volatile organic compounds (VOCs) such as alcohols and phenols that can be released into the air when using cleaning sprays or during storage (29).

Cooking activities produce several pollutants such as aldehydes, nitrogen dioxide, carbon monoxide, carbon dioxide and terpenes (30). Without proper ventilation or using the hoods, these pollutants can accumulate in the air and negatively affect indoor air quality, representing about half of indoor pollutants emissions (31).

Air fresheners often contain chemicals and fragrances that can release pollutants into the air, including VOCs and particulate matter (32).

The use of chemical-based insecticides indoors can release harmful pollutants into the air too (33). These pollutants can linger in the air for an extended period and potentially cause respiratory issues (34).

Finally, dust, pet dander, and other allergens can accumulate over time if regular cleaning is neglected. Indoor dust contains various chemicals, such as phthalates, fragrance, flame retardants, and phenols associated with health hazards such as cancer, endocrine/hormone disruption, and reproductive toxicity and contributes to poor indoor air quality and trigger allergies or respiratory problems (35).

In addition to chemicals, microorganisms, allergens and molds, physical agents can contribute to indoor air pollution, such as the presence of radon (36), electromagnetic radiation (37,38) and noise pollution (39).

Therefore, it is essential to pay the due attention to the behaviors to be adopted daily at home or at work (40).

It is important to take into account where people live, not only because urban and not-urban residents have different lifestyles, but also because outdoor air

is different in these two settings (41). For example, outdoor air in cities is polluted by vehicle exhaust gases (42) whereas in the countryside sources of pollution can be the intensive use of pesticides in agricultural activities (43). These pollutants can contaminate the air and have an impact on the indoor air quality too.

Indoor adequate ventilation eventually can be integrated by controlled mechanical ventilation (CMV) plants ensuring a correct air exchange in closed rooms to facilitate the evacuation of pollutants that can have negative effects on health, guaranteeing greater comfort and healthiness in the home, offices and schools (44). In addition to these systems, there are several plants that are known to be effective in reducing indoor air pollution by absorbing harmful pollutants and increasing the oxygen levels: spider plant (*Chlorophytum comosum*) is effective in removing formaldehyde, xylene, and carbon monoxide; peace lily (*Spathiphyllum*) removes formaldehyde, xylene, toluene, benzene, trichloroethylene, and ammonia; snake plant (*Sansevieria trifasciata*) is known for its ability to absorb formaldehyde, xylene, toluene, benzene, and trichloroethylene; aloe vera (*Aloe barbadensis*) is effective in removing formaldehyde and benzene; English ivy (*Hedera helix*) helps in reducing mold spores and absorbs formaldehyde; bamboo palm (*Chamaedorea seifrizii*), is known for removing formaldehyde, xylene, and toluene; rubber plant (*Ficus elastica*) absorbs formaldehyde and other pollutants (45,46).

Knowledge about indoor air pollution is influenced by several factors including education levels, socioeconomic status, personal experiences, and access to information (47). Besides, a greater knowledge not necessarily results in proper attitudes and behaviors.

For this reason, the aim of this work was to evaluate among the general population their knowledge about indoor air pollution, their daily habits related to this issue and the adopted preventive behaviors in order to contrast or mitigate the effects on health caused by indoor pollutants.

Methods

Setting and sample collection

The study was conducted between February and September 2023 through the administration of an anonymous questionnaire, elaborated ad hoc and based on multiple-choice questions. It was created with Google Forms and consists of four sections: sociodemographic characteristics (sex, age, residence), knowledge, daily habits and preventive behaviors.

The inclusion criteria required to be selected in the study were: age ≥ 18 years, residence in the metropolitan city of Messina (Sicily, Italy) and speaking Italian language.

The questionnaire was distributed both online through messaging app (especially WhatsApp) and social networks (Facebook) and face-to-face.

We had a 26.3% non-response rate and therefore the study was carried out on a convenience sample, because it enrolled every subject who replied to the questionnaire.

Before the administration, the interviewees were informed about the aim of the study and that their participation was on voluntary and free basis. After individual consent, the questionnaire was completed by all the participants without any difficulty in 15 minutes or less.

This cross-sectional study was developed in accordance with the Helsinki declaration.

Statistical analysis

All the statistical variables surveyed were summarized by means of frequency distributions. All analysis were performed using Epi info software.

Results

Socio-demographics characteristics of the sample

The questionnaire was filled by 894 subjects; 418 (46.8%) were males and 476 (53.2%) females. We divided the sample in three groups: 174 (19.5%) were under-25; 387 (43.3%) aged between 25 and 50 years; 333 (37.2%) over-50s (Table 1).

Results on the total sample.

About two thirds of the interviewees (66.8%, n = 598) had heard of indoor air pollution. A higher majority (84.6%, n = 745) provided the correct definition of indoor air pollution and 94.9% (n = 844) knew what the most common indoor pollutants are, indicating household cleaning products, deodorants, mold, dust and cigarette smoke as indoor pollutants. Almost all knew that cigarette smoking pollutes (99.7%, n = 891).

The study participants were largely aware that furniture can contain and release pollutants (88.2%, n = 786) as well as resins, disinfectants, insulators and germicides (72.1%, n = 645).

Table 1 - Socio-demographic characteristics of the sample.

	N (894)	%
Gender		
Male	418	46.8
Female	476	53.2
Age		
Under-25	174	19.5
Between 25 and 50	387	43.3
Over-50	333	37.2
Life:		
In a city	414	46.3
In the countryside/in the mountains	273	30.5
By the sea	207	23.2
Live near:		
Industries or factories, landfills or former asbestos quarry	231	25.8
Farms and nurseries	357	39.9
None of the above	306	34.2
Live with smokers:		
Yes	261	29.2
No	633	70.8

As regards the knowledge about carpets, curtains and rugs, the majority knew that they cause indoor pollution and trap pollutants; only 2% (n = 19) responded that they do not release pollutants. It emerges that 85.6% (n = 765) was aware that cleaning products can release pollutants into the air; besides, 87.8% (n = 782) believed that keeping some plants at home can help reduce pollutants dispersed indoors.

All the answers about knowledge on indoor air pollution are summarized in Table 2.

Most of our sample were aware of the attitudes to be adopted to reduce indoor pollutants, such as using the hood while cooking (80.9%), cleaning the shoes on the doormat before entering the house (78%) and dusting and sweeping daily (88.6%) (Figure 1).

Daily habits

A large majority of our sample (97.4%, n = 870) declared to air the house several times a day, 91.9% (n = 822) did it in the morning and during (97.6%, n = 729) and after (71.4%, n = 396) cleaning.

As regards tobacco smoking, 24.8% (n = 222) of the interviewees were smokers and 9.1% (n = 81) of the total had the habit of smoking indoors.

About the use of insecticides 85.9% (n = 768) responded that they did not use them at home, while 55.4% (n = 495) of the sample responded that they used air fresheners.

All the answers about the daily habits of the sample are summarized in Table 3.

Table 2 - Knowledge of the sample about indoor air pollution.

Questions	Right answer (%)	Wrong answer (%)
What is the definition of indoor air pollution?	84.6	15.4
What are the most common indoor pollutants?	94.9	5.1
Does cigarette smoking pollute?	99.7	0.3
Can furniture contain and release pollutants?	88.2	11.8
Do carpet, curtains and rugs cause indoor pollution, trap pollutants such as mold spores, other debris, dust mites and pet hair?	98.0	2.0
Do resins, disinfectants, insulators and germicides pollute?	72.1	27.9
Do cleaning products release pollutants?	85.6	14.4
Can keeping some plants at home help reduce pollutants dispersed indoors?	87.8	12.2

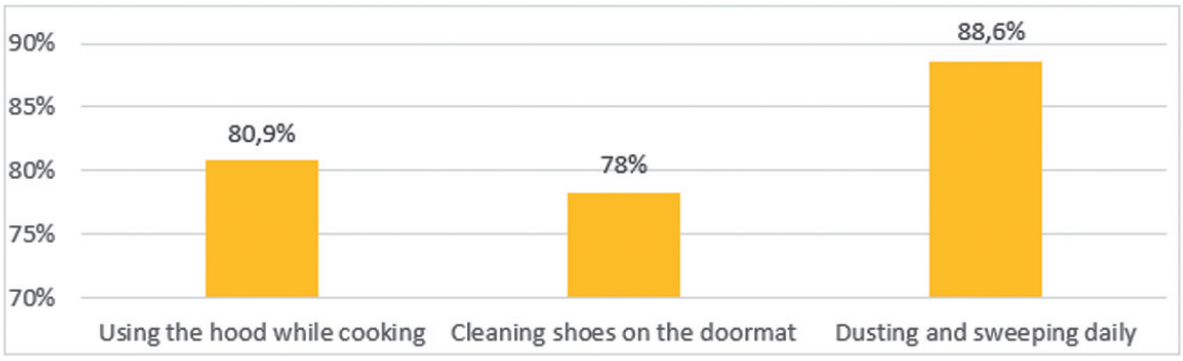

Figure 1 - Knowledge about preventive behaviors.

Table 3 - Daily habits of the sample.

Questions	Yes (%)	No (%)
Do you air out the house several times a day?	97.4	2.6
Do you air out the house in the morning?	91.9	8.1
Do you air out the house during cleaning?	97.6	2.4
Do you air out the house after cleaning?	71.4	28.6
Do you turn on the hood or open the windows while cooking?	91.6	8.4
Are you a smoker?	24.8	75.2
Under-25s	*27.6*	*72.4*
Between 25 and 50 years	*29.5*	*70.5*
Over-50s	16.2	83.8
If yes: Do you smoke indoors?	36.7 of smokers (9.1 on total)	63.3 of smokers (90.9 on total)
Do you regularly use insecticide?	14.1	85.9
Do you use air fresheners?	55.4	44.6
Do you prefer “organic” cleaning products?	47.3	52.7

Preventive behaviors

More than a third of the sample bought cleaning products without considering their characteristics (37.2%, n = 332), 86.9% (n = 803) turned on the hood while cooking and 81.9% (n = 732) carefully and periodically washed curtains and carpets. Only about a third of the interviewees bought plants able to purify indoor environments (32.9%, n = 294).

All the answers about the preventive behaviors of the sample are summarized in Table 4.

In the Figure 2 the answer to the question “Do you choose the cleaning product based on?” are reported.

Key results

More than 9 out of 10 of under-25s (91.4%, n = 159) knew that cleaning products release pollutants into the air, unlike only 78.4% (n= 261) of over-50s. On the other side, 82% (n= 273) of over-50s carried out periodic maintenance of air conditioners, a higher percentage of under-25s (67.2%, n= 117).

City residents had greater knowledge of what the most common indoor pollutants are (97.8%, n = 405), compared to residents in the countryside/ mountains (91.2%, n = 249) and seaside (91.3 %, n = 189). Who lived in the countryside on in the mountains took greater account of the characteristics of cleaning products (73.6%, n = 201) than who liked somewhere else. Analogously, who lived near farms or nursery paid more attention to the label in the choice of cleaning products (47.9%, n = 171).

Almost all of those who have heard of indoor air pollution (93%, n = 555) knew that furniture contain and release polluting substances, unlike 22.2% (n = 66)

Table 4 - Preventive behaviors of the sample.

Questions	Yes (%)	No (%)
Do you take the characteristics of a product into account when purchasing it?	62.8	37.2
Do you turn on the hood while cooking?	86.9	13.1
Do you carry out periodic maintenance of air conditioners and any stoves?	79.2	20.8
Do you periodically clean the air conditioning filters?	90.6	9.4
Do you carefully and periodically wash curtains and carpets?	81.9	18.1
Do you buy plants able to purify indoor environments (e.g. spider plant, peace lily, snake plant, aloe vera, English ivy)?	32.9	77.3

who have never heard of it. A similar percentage of the first ones (89,9%, n = 537) were aware that cleaning products release pollutants, differently from those who had never heard of it (76.8%, n = 228). The majority of those who had heard of indoor pollution (51.3%, n = 306) preferred "organic" cleaning products, unlike 39.4% (n = 117) of those who had not heard of them. A large share of the interviewees informed about this issue bought plants able to purify indoor environments (39.7%, n = 237), unlike 19.2% (n = 57) of the other ones and chose cleaning products based on the label (41,7%, n = 249), differently from the other ones that chose them based on habit (46,5%, n = 138).

Non-smokers had a better knowledge than smokers about indoor air pollution and bought to a greater extend plants that purifying indoor environments.

Among indoors smokers, 92.6% (n = 75) did not habitually use insecticides, while 23.4% (n = 33) of those who did not smoke indoors habitually used them.

About a quarter of indoors smokers (25.9%, n = 21) never turned on the hood when cooking; 93.6% (n = 132) of those who did not smoke indoors always or often turned on it.

Those who opened doors and windows to ventilate after cleaning: used less air fresheners (53.6%, n = 426) than those who did not do so (69.7%, n = 69); took more into account the characteristics of cleaning products before purchasing (64.5%, n = 513) choosing mainly them based on their labels (37.4%, n = 297) than those who did not do so (48.5%, n = 48), choosing mainly them based on habit (60.6%, n = 60).

No statistically significant differences by gender were detected.

All the remarkable results are reported in Table 5.

Discussion

The results of our study show that most of the interviewees had a good knowledge about indoor air pollution: they largely knew what the correct definition is and what the most common indoor pollutants are. Nevertheless, it is necessary to highlight that only

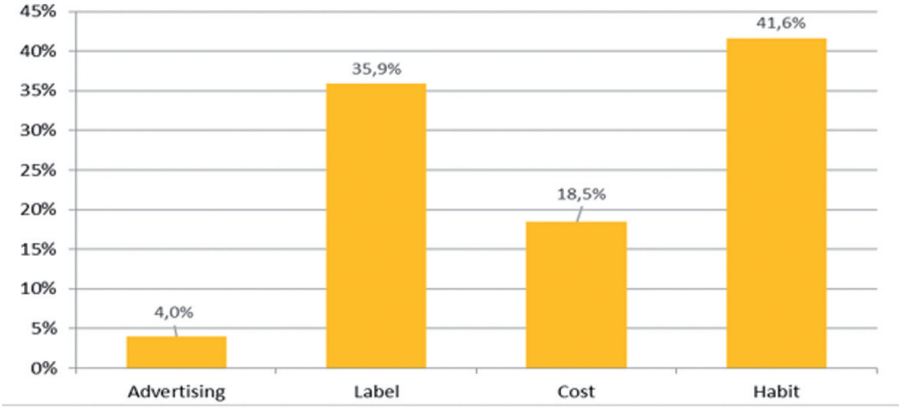

Figure 2 - Leading factors in the choice of the cleaning products.

Table 5 - Key results.

		%		
Age		Under-25s	Between 25 and 50	Over-50s
I know that cleaning products release pollutants		91.4	89.1	78.4
I carry out periodic maintenance of air conditioners		67.2	82.2	82.0
Residence		In a city	In the countryside/ in the mountains	By the sea
I know what the most common indoor pollutants are		97.8	91.2	91.3
I take the characteristics of cleaning products into account before purchasing		59.4	73.6	55.1
		Farms and nursery	Other (landfill, industries, etc)	None of the above
I choose cleaning products based on:	Label	47.9	28.6	27.5
	Habit	35.3	44.2	47.1
Information: Have you ever heard of indoor air pollution?			Yes	No
I know the correct definition of indoor air pollution			88.4	72.7
I know that furniture contain and release pollutants			93.0	77.8
I know that cleaning products release pollutants			89.9	76.8
I know that keeping some plants at home helps to reduce indoors pollutants			90.5	80.8
I prefer “organic” cleanig products			51.3	39.4
I take the characteristics of cleaning products into account before purchasing			68.3	51.5
I choose cleaning products based on:	Label		41.7	24.2
	Habit		39.2	46.5
I buy plants that purify environments			39.7	19.2
Smoking habits			Smokers	Non-Smokers
I live with smokers			67.6	16.5
Carpets, curtains and rugs cause indoor pollution and trap pollutants			94.6	99.1
I buy plants that purify environments			18.5	44.7
Do you open doors and windows after cleaning?			Yes	No
I use air fresheners			53.6	69.7

about two thirds of the sample had ever heard about this phenomenon.

Therefore, as expected, people informed about indoor pollution had a better knowledge about this topic than not-informed ones, as demonstrated by the several statistical differences between these two subsamples. In addition, the better knowledge led the informed people to adopt more suitable behaviors: for example, they took the characteristics of a product into account before purchasing it to a greater extent than not-informed people, they chose the cleaning products based on label rather than on habit and a higher percentage of them bought plants able to purify environments.

The information about this issue can be related to the educational level of people: those who have access to educational resources may be more knowledgeable about the topic. This is consistent with a previous research by Montouri et al. (48), carried out in the metropolitan city of Naples, in which people with a high education level were the 62.91% of the total sample, a similar percentage (66.8%) of our sample that declared to be informed about indoor air pollution. An analogous mean score (68.19%) was found by a French study of Daniel et al. (47) enrolling adults 18-45 years old.

Therefore, our findings confirm that relationships between knowledge and educational level exists and between knowledge about pollution and educational level also exists (49).

A further consideration can be made regarding the link between age and knowledge: younger people

had a better awareness of indoor air pollution, as shown in our study in which a higher percentage of under-25 (91.4%) knew that cleaning products release pollutants into the air. Besides, the knowledge about this statement decreased with age and, in fact, only 78.4% of the over-50s was able to answer correctly this question. This statistically significant finding, showing a declining trend of knowledge with increasing age, is in accordance with a study by Qian et al. (50) carried out in the Chinese city of Ningbo.

The residence of the sample plays an important role concerning daily habits: those who lived in the countryside and in the mountains considered the characteristics of the cleaning products before buying to a greater extent than people living in cities or by the sea. Similarly, those who lived near farms and nurseries are guided by the label in purchasing cleaning products, unlike the other ones who live somewhere else, that are guided by habit. These detections are interesting because no previous research evaluated living places in the attitudes towards indoor air pollution.

Overall, although people had adequate knowledge and awareness of the indoor air pollution phenomenon, this did not strongly impact on the adoption of proper lifestyles. Therefore, there is a contrast between what was known and what was done: in fact, some data reveal that the analyzed population was reluctant to abandon their lifestyle habits even to the detriment of their health.

This finding is in line with previous studies: Daniel et al. stated that well-integrated practices are not related to knowledge and level of education (47); Montouri et al. hypothesized that some incorrect behaviors are due to the fact that are actions performed repeatedly in daily life (48).

In fact, as regards environmental tobacco smoking, almost all (99.7%) knew that tobacco smoking causes pollution, but a consistent amount (24.8%) was composed by smokers and even 9.1% of the total used to smoke indoors. This result is in line with the data of the Italian National Institute of Health (in Italian, *ISS, Istituto Superiore di Sanità*), stating that 24.2% of the Italian adult population is composed by tobacco smokers (51,52). Among young people, the percentage of smokers is increasing: in our study we detected 27.6% of young smokers, a higher percentage than those ones noticed in previous studies (53). Even this data is consistent with the Italian NIH report (52). These agreements allow us to probably affirm that our results could be representative of the Italian general population.

Another discrepancy is also revealed in the choice of cleaning products: in fact, despite 85.6% of the subjects knew that cleaning products release polluting substances into the air, only 71.4% aired out the house after cleaning and only 62.8% considered the characteristics of the product before buying.

Similar considerations can be made regarding carpets, curtains and rugs (98% knew they cause indoor air pollution, but only 81.9% periodically and carefully washed them) and regarding the purchase of plants able to reduce the concentration of indoor pollutants (87.8% were aware that they can help, but only 32.9% buy them).

Conclusions

Our study shows that there is still a need for better knowledge and awareness about indoor air pollution. Indeed, everyone is not aware of the potential sources of indoor air pollution such as household cleaning products, environmental tobacco smoke, building materials, and poor ventilation and of their health effects such as respiratory issues, allergies, and asthma.

In a constantly evolving cultural horizon we must also take social inequalities into account; in fact, people such as the elderly and children belonging to disadvantaged social classes are more at risk (54,55) because they are more exposed to behaviors at risk (56) such as passive smoke, cooking food without adequate ventilation systems (20) and inadequate cleaning of environments; in addition, they have a worse awareness of the problem of indoor air pollution and a more difficult access to information and medical treatment (57).

Precisely for this reason, it becomes necessary to intervene on a social level with environmental education activities on indoor air quality and health education with persuasive interventions, starting from school age (58).

In addition, it is necessary to make the entire population aware of the choices they make. Daily choices positively or negatively influence their health. People often follow their habits not considering that some of these attitudes and behaviors have consequences on the others and on the environment too.

Efforts should be made to improve awareness through educational programs, public health campaigns, and access to information on prevention and mitigation strategies. These initiatives aim to

inform individuals about the sources, risks, and prevention strategies related to indoor air pollution. For this purpose, public health specialists are the most appropriate professionals capable of strengthening these strategies, leading everyone to make the right choice and to reduce the impact of many risk factors (59).

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Riassunto

Inquinamento indoor: uno studio di Conoscenza, Atteggiamenti e Pratica (CAP) condotto in Italia sulla popolazione generale

Introduzione. L'inquinamento dell'aria indoor incide negativamente sulla salute della popolazione e sui servizi sanitari nazionali in termini di costi socio-economici. La presenza di inquinanti indoor dipende molto dagli stili di vita.

Disegno dello studio. Lo scopo di questo lavoro è quello di valutare le conoscenze, le abitudini quotidiane ed i comportamenti preventivi per contrastare gli effetti sulla salute causati dagli inquinanti indoor.

Metodi. Lo studio è stato condotto attraverso la somministrazione di questionari alla popolazione residente nella città metropolitana di Messina (Italia), chiedendo informazioni su caratteristiche socio-demografiche, conoscenze, abitudini quotidiane e comportamenti preventivi.

Risultati. Il questionario è stato compilato da 894 soggetti (46,8% M; 53,2% F). Per quanto riguarda la conoscenza, il 66,8% aveva sentito parlare di inquinamento dell'aria indoor e il 94,9% sapeva quali sono gli inquinanti indoor più comuni; per quanto riguarda le abitudini quotidiane arieggiavano spesso la casa (il 91,9% al mattino e il 71,4% dopo le pulizie), il 24,8% erano fumatori e di questi il 36,7 fumava in ambienti chiusi; per quanto riguarda i comportamenti preventivi, il 41,6% sceglieva i prodotti per la pulizia in base all'abitudine e solo il 32,9% acquistava piante in grado di purificare gli ambienti.

Conclusioni. Nonostante la popolazione analizzata avesse un'adeguata conoscenza dell'inquinamento dell'aria indoor, ciò non ha avuto un forte impatto sull'adozione di stili di vita sani. Diventa quindi necessario intervenire a livello sociale con attività di educazione ambientale, a partire dall'età scolare.

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