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Risk perceptions of a population living near a municipal waste incinerator and associated factors with the prevalence of environmental disease

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ABSTRACT

Background: This study investigated the risk perceptions, prevalence of environmental diseases (EDs) and associated factors with the prevalence of environmental disease among the population living near an incinerator

Methods: Study area were divided into 3 local areas near the incinerator by distance (A, B, C) and control area (D) by distance and geographic isolation. A Questionnaire was conducted with 1,380 in local residents (A, B, C) and 390 in control area (D), gathered information of demographic characteristics, lifestyle, perception of damage by incinerators, experience of EDs (atopic dermatitis, allergic rhinitis, asthma) diagnosed by physician. Analysis of variance, χ^2 test, and Kruskal Wallis test was applied to determine the difference by area. Logistic regression analysis was performed to identify factors associated with the prevalence of allergic rhinitis.

Results: Residents residing closer to the incinerator had negative perception in most items in questionnaire compared with control. The prevalence of allergic rhinitis was higher as they lived nearby the incinerator ($p = 0.008$). The associated factors with the prevalence of allergic rhinitis were carpet (odds ratio [OR]: 1.79, $p = 0.001$), residential area (marginally significant), duration of residence (OR: 1.09, $p < 0.001$). The perception of environmental pollution around the residential area was inversely associated with the prevalence of allergic rhinitis: perceived as very dissatisfied (OR: 4.21, $p = 0.02$) compared with very satisfied.

Conclusions: As closer to the incinerator, the risk perception tend to negative and prevalence of EDs were increased. Carpet, residential area, duration of residence and perception of environmental air pollution around the residential area were associated with prevalence of allergic rhinitis. These results may be useful for the communication with residents to discuss the environmental problems caused by the incinerator.

Keywords: Environmental diseases; Incinerator; Perception; Prevalence

BACKGROUND

Incineration is the most efficient method to reduces waste volume and weight.[1] Also, some incineration plants harvest energy when incinerating waste, which helps mitigate the global

energy supply problem.[2] However, incinerators can emit harmful substances (dioxin, lead, cadmium, and mercury),[3] and local residents perceive them negatively.[4] In Korea, incinerators are often built near residential areas, leading to frequent conflicts between local governments and residents[5] regarding the environmental pollution and health problems caused by the substances listed above. One survey of residents living near an incinerator revealed that they believed the incinerator caused significant harm, particularly to health.[6] A previous study reported on heavy metal exposure of residents living near Korean incinerators found that incinerator operation did not affect blood lead, cadmium, or mercury levels.[7] A study on children found no relation between incinerator operation and the incidence of allergic rhinitis or atopic dermatitis within populations in the surrounding area.[8] However, a study reported increased blood polychlorinated dibenzo-p-dioxins/dibenzofurans concentrations in residents living near incinerators and incinerator workers.[9] Also, emissions of carcinogenic substances (chromium, arsenic, cadmium, and nickel) by incinerators in a new city exceeded the levels permitted by the Ministry of Environment.[10] The burden of disease due to PM_{10}, NO_2, SO_2, and CO emitted by incinerators was about 297 person-years in Seoul in 2007. Therefore, although the emissions are low, the disease burden may be significant from a public health perspective.[11]

The results of Korean studies on health effects caused by incinerators remain controversial; the results differ by the type of incinerator and materials emitted. Residents living near incinerators are very concerned about environmental diseases (EDs) and other health risks; they tend to view incinerators negatively and sometimes demand incinerator safety improvements or relocation[5]. However, the negative perceptions may exceed the actual health risks. To date, no report has compared the actual effects of incinerator operation (in terms of EDs) with the risk perceived by residents. This study aimed to investigate the perceptions of environmental pollutions around the residential area and perceived damaging effects caused by the incinerator as well as the prevalence of EDs and factors associated with the prevalence of EDs.

METHODS

Study area
The study area was divided into four residential areas according to the distance and geographic isolation from the incinerator: A within about 0.4 km; B within 0.4–3.2 km; C within 3.3–6.5 km and D > 8.6 km. Area A, B, C are not geographically isolated, but open area in one direction from the incinerator. Area D (control area) is geographically isolated from incinerator, including mountains. The area A, B, C were within the vicinity of a stocker-type incinerator in Gimhae city, which has burnt less than 150 tons of household waste daily for about 20 years. A semi-dry reaction tower, bag filter, and "selective catalytic reaction tower" are used to prevent air pollution.

Questionnaire survey
The questionnaire was completed by 1,800 subjects aged 19–70 years who had lived in areas around the city during March to June, 2020. The subjects were selected from household registries established by the Korean Ministry of the Interior and Safety (2019) to represent the overall population distribution of each area based on sex, and age. Among the 1,800 people who completed the questionnaire, 30 residents who lived before the operation of the incinerator were excluded. There were 592 residents in area A and 388, 400 and 390 in areas B, C, D, respectively. The structured questionnaire was administered during a home visit by a professional researcher of specialized agency by random selection.

The questionnaire included the following items: sociodemographic characteristics (sex, age, smoking status, alcohol consumption and duration of residence, education level, monthly income), 4 lifestyle factors (pets at home, carpets at home, air purifier at home and exercise). Participant who smoked more than 20 packs of cigarettes in life time was classified as smoker. For alcohol consumption, those who drank > 1 time per month were classified as drinkers. Participants who performed regularly either low-level or mid-level exercise more than 1–2 times per week were classified as yes of exercise. In addition, the questionnaire included on perceptions of environmental pollutions around the residential area (air pollution, water pollution, soil pollution, odor and noise), perceptions of environmental pollution caused by the incinerator (air pollution, foul odor, noise), perceptions of health, economic and psychological damage caused by the incinerator (impact on health, psychological impact, economic impact, property value impact, neighborhood value impact and considering moving because of the incinerator). These items were scored on a 5-point Likert scale (5 = very dissatisfied, 1 = very satisfied). In addition, the questionnaire included data on perceptions of incinerator operation status which includes knowledge that incinerator existed, efforts made to ensure safe operation and trust in publicly available information about the incinerator. Two items ("Efforts made to ensure safe operation" and "Trust in publicly available information on incineration") were scored using 7-point Likert scales (where higher scores reflect more negative perceptions). Finally, questionnaire survey was carried out to find respondents who had been diagnosed with atopic dermatitis, allergic rhinitis, asthma by a physician while living in their current home (including nearby areas). EDs were defined as person who diagnosed by physician at the least one of three diseases such as atopic dermatitis, allergic rhinitis, asthma.

Statistical analysis

The χ^2 test was applied to compare regional differences in EDs such as atopic dermatitis, allergic rhinitis or asthma diagnoses by physicians, and in the proportions of respondents who stated that had been diagnosed with EDs by a physician while living in their current home (including nearby areas). Likert scale score of the questionnaire data were averaged. Analysis of variance, χ^2 test, and Kruskal-Wallis test was applied to determine if the results differed by area. Finally, data from areas A–D were subjected to logistic regression analysis to determine whether sociodemographic characteristics and perception of environmental air pollution around the residential area associated with the prevalence of physician-diagnosed EDs (allergic rhinitis as dependent variable because prevalence was significantly different among the study areas). The independent variables were the residential area, sex, age, smoking status, alcohol consumption, pets at home, carpets at home, duration of residence, and perception of air pollution around the residential area. Variables suspected of multicollinearity and variables known to be irrelevant with EDs were excluded. The statistical analysis was performed using IBM SPSS ver. 25 software (IBM Corp., New York, NY, USA).

Ethics statement

The present study conducted questionnaire survey on 1,800 subjects in 2020.06–2020.07 and received approval from the Inje University Busan Paik Hospital Institutional Review Board (IRB file No. BPIRB 2020-01-009-006). All participants signed a written informed consent to take part in the study under the specified conditions.

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RESULTS

The sociodemographic characteristics are shown in **Table 1**. Sex distribution, age distribution, smoking status and pet at home did not differ significantly among the study areas. However, alcohol consumption, carpets at home, air purifiers at home, exercise, duration of residence, education level and monthly income showed statistically significant differences among the study areas.

Table 1. Sociodemographic characteristics of questionnaire respondents

Parameter	Study area (distance from incinerator)				p-value
	A (< 0.4 km)	B (0.4–3.2 km)	C (3.3–6.5 km)	D[c] (8.6 km)	
Sex					0.987[a]
Male	298 (50.3)	191 (49.2)	199 (49.8)	193 (49.5)	
Female	294 (49.7)	197 (50.8)	201 (50.3)	197 (50.5)	
Age					0.593[a]
19–29	86 (14.5)	65 (16.8)	60 (15.0)	59 (15.1)	
30–39	96 (16.2)	61 (15.7)	68 (17.0)	79 (20.3)	
40–49	174 (29.4)	96 (24.7)	102 (25.5)	106 (27.2)	
50–59	116 (19.6)	74 (19.1)	74 (18.5)	61 (15.6)	
> 60	111 (18.8)	88 (22.7)	89 (22.3)	73 (18.7)	
Mean ± SD	47.5 ± 14.8	47.2 ± 15.8	47.3 ± 15.4	46.3 ± 15.1	0.693[b]
Smoking status					0.322[a]
Smoker	160 (27.0)	117 (30.2)	118 (29.5)	97 (24.9)	
Non-smoker	432 (73.0)	271 (69.8)	282 (70.5)	293 (75.1)	
Alcohol consumption					0.001[a]
Current drinker	374 (63.2)	293 (75.5)	266 (66.5)	258 (66.2)	
Non-drinker	218 (36.8)	95 (24.5)	134 (33.5)	132 (33.8)	
Pets at home					0.889[a]
Yes	93 (15.7)	68 (17.5)	68 (17.0)	64 (16.4)	
No	499 (84.3)	320 (82.5)	332 (83.0)	326 (83.6)	
Carpets at home					< 0.001[a]
Yes	67 (11.3)	82 (21.1)	74 (18.5)	105 (26.9)	
No	525 (88.7)	306 (78.9)	326 (81.5)	285 (73.1)	
Air purifiers at home					0.001[a]
Yes	304 (51.4)	181 (46.6)	184 (46)	231 (59.2)	
No	288 (48.6)	207 (53.4)	216 (54.0)	159 (40.8)	
Exercise					< 0.001[a]
Yes (≥ 1–2 times/week)	436 (73.6)	324 (83.5)	334 (83.5)	250 (64.1)	
No	156 (26.4)	64 (16.5)	66 (16.5)	140 (35.9)	
Duration of residence					< 0.001[a]
< 2	75 (12.7)	71 (18.3)	110 (27.5)	101 (25.9)	
3–6	165 (27.9)	90 (23.2)	122 (30.5)	85 (21.8)	
7–10	159 (26.9)	112 (28.9)	112 (28)	76 (19.5)	
11–14	93 (15.7)	48 (12.4)	37 (9.3)	59 (15.1)	
> 15	61 (10.3)	43 (11.1)	4 (1.0)	44 (11.3)	
Mean ± SD	8.6 ± 5.0	8.2 ± 5.1	5.8 ± 4.1	7.7 ± 5.7	< 0.001[b]
Education level					< 0.001[a]
Less than high school	67 (11.3)	67 (17.3)	47 (11.8)	54 (13.8)	
High school	221 (37.3)	221 (57.0)	99 (24.8)	128 (32.8)	
College or higher	304 (51.4)	304 (78.4)	254 (63.5)	208 (53.3)	
Monthly income (× 1,000 won)					< 0.001[a]
< 1,000	32 (5.4)	31 (8.0)	15 (3.8)	10 (2.6)	
1,000–2,999	170 (28.7)	99 (25.5)	82 (20.5)	141 (36.2)	
3,000–4,999	305 (51.5)	193 (49.7)	200 (50.0)	156 (40.0)	
≥ 5,000	85 (14.4)	65 (16.8)	103 (25.8)	83 (21.3)	

Values are presented as number of residents (%).
SD: standard deviation.
[a] χ^2 test; [b] Analysis of variance; [c] Control area.

Data on the perceptions of environmental pollutions around the residential area and perceived damaging effects caused by the incinerator are shown in **Table 2**. Residents in area A responded negatively to all items, while those in area B were also more negative than area D residents. However, area C residents were at least as positive about the incinerator as area D residents. In particular, 64.4% and 18.8% of area A and B residents, respectively, stated that they were considering moving because of environmental problems; the proportion for area D was 5.9%.

The prevalence of EDs among the study areas are shown in **Table 3**. The prevalence of EDs showed a tendency to increase with closer proximity to the incinerator. The number of physician-diagnosed allergic rhinitis increased significantly ($p = 0.008$) with closer proximity to the incinerator. However, atopic dermatitis and asthma did not show statistical significance among the study areas.

Table 4 presents the results of the logistic regression of factors associated with the prevalence of physician-diagnosed allergic rhinitis. Factors such as sex, age, smoking status, alcohol consumption and pets at home were not associated with the prevalence of allergic rhinitis. However, residential area, carpets at home, duration of residence and perception of environmental air pollution around the residential area were associated with the prevalence of allergic rhinitis. The prevalence of allergic rhinitis was higher (marginally significant) in the area near the incinerator (A, B, C) compared with the control area (D) (area A, odds

Table 2. Perceptions of environmental pollutions around the residential area and perceived damaging effects caused by the incinerator

Parameters	Study area (distance from incinerator)				p-value
	A (< 0.4 km)	B (0.4–3.2 km)	C (3.3–6.5 km)	D (8.6 km)	
Perceptions of environmental pollutions around the residential area					
Air pollution	3.63 ± 0.82	2.86 ± 0.96	2.24 ± 0.73	2.41 ± 0.75	< 0.001[a]
Foul odor	4.01 ± 0.90	2.56 ± 1.09	2.03 ± 0.78	2.44 ± 0.83	< 0.001[a]
Water pollution	3.01 ± 0.64	2.25 ± 0.87	1.92 ± 0.69	2.18 ± 0.65	< 0.001[a]
Soil pollution	2.91 ± 0.59	2.24 ± 0.82	1.87 ± 0.66	2.17 ± 0.65	< 0.001[a]
Noise	3.22 ± 0.75	2.55 ± 0.93	1.98 ± 0.79	2.49 ± 0.87	< 0.001[a]
Perceptions of environmental pollution caused by the incinerator					
Air pollution	3.71 ± 0.76	3.00 ± 1.13	2.43 ± 0.95	2.88 ± 1.09	< 0.001[a]
Foul odor	4.07 ± 0.87	2.76 ± 1.33	2.20 ± 1.01	2.80 ± 1.17	< 0.001[a]
Noise	2.99 ± 0.74	2.15 ± 1.01	1.89 ± 0.84	2.51 ± 0.98	< 0.001[a]
Perceptions of health, economic and psychological damage caused by the incinerator					
Impact on health	2.83 ± 0.95	1.99 ± 0.99	1.70 ± 0.86	1.65 ± 0.60	< 0.001[a]
Psychological impact	3.63 ± 1.01	1.97 ± 1.14	1.57 ± 0.76	1.66 ± 0.64	< 0.001[a]
Economic impact	3.72 ± 1.08	2.06 ± 1.26	1.64 ± 0.86	1.63 ± 0.61	< 0.001[a]
Property value impact	4.26 ± 0.74	3.20 ± 1.12	2.59 ± 0.91	2.88 ± 1.17	< 0.001[a]
Neighborhood value impact	4.23 ± 0.74	3.14 ± 1.09	2.54 ± 0.97	2.83 ± 1.16	< 0.001[a]
Considering moving because of the incinerator, number of respondents (%)	381 (64.4)	73 (18.8)	19 (4.8)	23 (5.9)	< 0.001[b]
Perceptions of incinerator operation status					
Knowledge that incinerator existed, number of respondents (%)	546 (92.2)	339 (87.4)	338 (84.5)	218 (55.9)	< 0.001[b]
Efforts made to ensure safe operation[c]	4.93 ± 1.30	4.16 ± 1.54	4.03 ± 1.57	4.07 ± 0.95	< 0.001[a]
Trust in publicly available information about the incinerator[c]	5.17 ± 1.25	4.76 ± 1.74	4.96 ± 1.79	4.34 ± 1.01	< 0.001[a]

Values are presented as mean ± standard deviation or number of respondents (%).
[a]Kruskal-Wallis test; [b]χ² test; [c]7-point Likert scale; Higher scores reflect more negative perceptions.

Table 3. Prevalence of environmental diseases according to the distance from the incinerator

Parameters	Study area (distance from incinerator)				p-value[a]
	A (< 0.4 km)	B (0.4–3.2 km)	C (3.3–6.5 km)	D (8.6 km)	
Atopic dermatitis	8 (1.4)	3 (0.8)	1 (0.3)	1 (0.3)	0.132
Allergic rhinitis	55 (9.3)	33 (8.5)	21 (5.3)	17 (4.4)	0.008
Asthma	7 (1.2)	3 (0.8)	7 (1.8)	3 (0.8)	0.515

Values are presented as number of residents (%).
[a]χ² test.

Table 4. Logistic regression of factors associated with allergic rhinitis

Parameters	OR (95% CI)	*p*-value
Sociodemographic characteristics		
Residential area		
Area D (control area)	1.00	
Area A	1.33 (0.7–2.54)	0.39
Area B	1.75 (0.92–3.32)	0.09
Area C	1.79 (0.9–3.57)	0.10
Sex		
Male	1.00	
Female	1.51 (0.93–2.45)	0.10
Age (yr)		
19–29	1.00	
30–39	1.22 (0.61–2.45)	0.57
40–49	0.99 (0.54–1.82)	0.97
50–59	1.1 (0.58–2.09)	0.77
> 60	0.56 (0.28–1.12)	0.10
Smoking status		
Non-smoker	1.00	
Smoker	0.87 (0.48–1.56)	0.64
Alcohol consumption		
Non-drinker	1.00	
Current drinker	0.71 (0.47–1.07)	0.10
Pets at home		
No	1.00	
Yes	1.2 (0.74–1.94)	0.46
Carpets at home		
No	1.00	
Yes	1.79 (1.14–2.8)	0.01
Duration of residence	1.09 (1.05–1.13)	< 0.001
Perception of environmental air pollution around the residential area		
Very satisfied	1.00	
Satisfied	0.93 (0.31–2.76)	0.90
Neutral	1.38 (0.46–4.12)	0.56
Dissatisfied	2.65 (0.87–8.08)	0.09
Very dissatisfied	4.21 (1.25–14.16)	0.02

Adjusted for Sociodemographic characteristics (residential area, sex, age, smoking status, alcohol consumption, pets at home, carpets at home, duration of residence) and perception of air pollution around the residential area.
OR: odds ratio; CI: confidence interval.

ratio [OR]: 1.33, *p* = 0.39; area B, OR: 1.75, *p* = 0.009; area C, OR: 1.79, *p* = 0.10, compared with control area). The prevalence of allergic rhinitis in carpet at home yes group (OR: 1.79, *p* = 0.001) was significantly higher compared to carpet at home no group. The prevalence of allergic rhinitis was significantly increased as duration of residence (OR: 1.09, *p* < 0.001). In addition, perception of environmental air pollution around the residential area was associated with the prevalence of allergic rhinitis. As the degree of satisfaction with environmental air pollution around the residential area decreased, the prevalence of allergic rhinitis showed a tendency to increased: perceived as very dissatisfied (OR: 4.21, *p* = 0.02), dissatisfied (OR: 2.65, *p* = 0.09), neutral (OR: 1.38, *p* = 0.56), satisfied (OR: 0.93, *p* = 0.90) compared with very satisfied.

DISCUSSION

This study aimed to investigate the perceptions of environmental pollutions around the residential area and perceived damaging effects caused by the incinerator. Residents in areas near the incinerator had more negative perceptions than those of control area. In

addition, the residents in areas A and B stated that they were considering moving because of incinerator. In a previous study in Taiwan, there was no difference between the exposure group (near the incinerator) and the control group in risk perception regarding the incinerator unlike this study. However, the exposure group showed a significantly higher desire to move within one year or move sometime in the future than the control group like this study.[12] Although, there was a difference in the perception of the residents about the environmental pollution, physical, psychological and economic damage caused by the incinerator between the two studies, the desire to relocate was similar with each other. A previous study in Korea reported that the property price decreases as closer to incinerator.[13] In this study, the perception of economic damage caused by the incinerator was negative as closer to the incinerator. The property price decrease probably had an impact in a negative perception on economic damage caused by incinerators.

This study also aimed to investigate the prevalence of EDs among the study areas and factors associated with the prevalence of EDs focusing on allergic rhinitis. Our questionnaire data in adult indicated that an EDs history was about twice in areas A and B than area D. A questionnaire study conducted in Italy in adult reported that people living closer to an incinerator were at higher perceived risk of allergic rhinitis and acute/chronic lung disease due to incinerator similarly to this study.[6] In addition, according to a study on the combined heat and power generation (CHP) in Seoul using data from the National Health Insurance Sharing Service (NHISS), medical use of residents due to environmental diseases increased after the construction of the CHP,[14] which is also similar to the results of this study. According to the results of these studies in adults in Italy and Korea, it is evaluated that those who live closer to the incinerator have a higher prevalence of environmental diseases with higher perceived risk. In contrast, a questionnaire study conducted on children in Japan reported a different report from this study. There was no correlation between proximity to incinerators and asthma, allergic rhinitis, or atopy in children.[8] Further studies are needed to address these differences in children and adults.

In a review article by Chong and Chew (2018),[15] the associated factor that increased the prevalence of allergic rhinitis was reported as carpets, pets, exposure to air pollution, smoking and alcohol consumption. In this study, smoking, drinking and pets at home was not associated with the prevalence of rhinitis, although carpet, residential area (distance and geographical isolation from incinerator), duration of residence and perception of environmental air pollution around the residential area were associated with prevalence of the physician-diagnosed allergic rhinitis in respondents.

Carpets retain insect and fungal waste, fungal spores and house dust mite fecal proteins, thus carpet is known to be increasing the risk of allergic rhinitis.[15,16]

In this study, the prevalence of allergic rhinitis was higher (marginally significant) in the area around the incinerator (A, B, C) than in the control area (D) which is geographically isolated from incinerator. Also, the prevalence was increased according to the length of residence. In a similar study conducted in young adult in Japan, there was no evident relationship between the distance from incinerator and the prevalence of allergic rhinitis.[8] Depending on the size, combustion type and the actual emission of hazardous substances, the impact on the prevalence of environmental diseases in the surrounding area of incinerator may be different. However, there are insufficient studies on the relationship among the residential area, period of residence and the prevalence of environmental diseases. In our opinion, as the residential

period increased, residents become more informed about environmental issues in the area where they live, and perception of health effects caused by environmental pollution may be tends to negative, which may have influenced the medical use.

In this study, the prevalence of allergic rhinitis showed a tendency to increase as the degree of satisfaction with environmental air pollution around the residential area decreased. A similar result was reported in a survey of young adults in Italy: the perception of air pollution inversely associated with allergic rhinitis.[17] Another study reported the prevalence were several times higher in children with environmentally worried parents.[18] According to a study conducted in the same area as this study (2021), air pollutants such as PM_{10} and SO_2 and NO_2 were positively associated with the medical usage rates of environmental disease including allergic rhinitis.[19] The perceived exposure influences symptoms. Also, the effect of perceived exposure on disease is mediated by health risk perception.[20] All of these studies with this study, it is estimated that the perception of environmental pollution around the residential area is inversely associated with the prevalence of allergic rhinitis among residents living near the incinerator.

This study had several limitations. Although we included more respondents than previous studies, we could not confirm whether respondents were actually diagnosed with an EDs in the past. Only a few respondents reported a history of atopic dermatitis or asthma. For this reason, factor analysis associated with environmental diseases was performed on allergic rhinitis only. As this study was cross-sectional, data on chronological relationships were lacking. Residents who perceived damaging effect by the incinerator may have relocated prior to the survey. Thus, survival bias may have been present; some residents may be less sensitive to the adverse effects of incinerators than others. Finally, as described above, residents living near the incinerator become more informed about environmental issues and the perception on the health effects may be tends to negative, which may have influenced in deciding to participate the questionnaire, and medical use rate due to environmental problems as well as may have recalled experience of diagnosis more accurately.

CONCLUSIONS

Residents living close to the incinerator responded negatively to most questionnaire items about the perceptions of environmental pollutions around the residential area and perceived damaging effects caused by the incinerator, unlike those in the control area. The prevalence of EDs were more likely with closer proximity to the incinerator. Carpet, residential area, duration of residence and perception of environmental air pollution around the residential area were associated with prevalence of allergic rhinitis. These results may be useful for the communication with residents to discuss the environmental problems caused by the incinerator.

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