Lung health among plumbers and pipefitters in Edmonton, Alberta

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Abstract

Objectives—A cross sectional study was undertaken to assess lung health among plumbers and pipefitters. Respiratory symptoms, lung function, and radiographic changes among 99 actively employed plumbers and pipefitters with ≥ 20 years of union membership were compared with 100 telephone workers.

Methods—A respiratory symptom questionnaire was administered, including smoking and occupational histories. Spirometry was conducted according to standard criteria. Posteroanterior chest radiographs were evaluated by two experienced chest physicians, with a third arbitrating disagreed films. Members of the union were categorised as pipefitters ($n=57$), plumbers ($n=16$), or welders ($n=26$), based on longest service, and compared with the telephone workers and internally (between groups). Lung health was also compared with employment in several work sectors common to Alberta for time, and for time weighted by exposure to dust and fumes.

Results—Compared with the telephone workers, plumbers and pipefitters had more cough and phlegm, lower forced vital capacity, and more radiographic changes (20% with any change), including circumscribed (10%) and diffuse pleural thickening (9%). None of the plumbers and pipefitters had small radiographic opacities. Among the three subgroups of workers, plumbers had the highest prevalence of radiographic changes. Both plumbers and pipefitters showed higher odds ratios for cough and phlegm than the welders. No differences between groups were found for lung function. Indicators of lung health were not related to work in any sector.

Conclusions—Plumbers and pipefitters had increased prevalence of symptoms suggestive of an irritant effect with no evidence of bronchial responsiveness. The chest radiographs showed evidence of asbestos exposure, especially in the plumbers, but at lower levels than previously reported. Health screening programmes for these workers should be considered, although the logistical problems associated with screening in this group would be considerable.

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Keywords: construction workers; plumbers; pipefitters; welders; epidemiology; asbestos; lung function

Plumbers and pipefitters are responsible for the installation and maintenance of pipes and fixtures for substances including water, steam, chemicals, refrigerants, and hot and cold air. As part of their work they are exposed to welding fumes, insulation materials, and solvents. On construction sites they are also exposed to the activities of other trades workers. During maintenance operations they can encounter various substances, depending on the specific industry and process.

Previous studies have examined overall mortality,¹⁻³ mesothelioma,⁴ cancer incidence,⁵ and morbidity⁶ in plumbers and pipefitters. Studies of mortality and cancer incidence have shown modest increases in lung cancer among plumbers and pipefitters.^{1-3 5} A history of ever working as a plumber or pipefitter was significantly more common among 150 men diagnosed with malignant mesothelioma or primary malignant pleural tumours in Connecticut from 1955 to 1977, compared with a random sample of decedents from Connecticut.⁴ A cross sectional study of 153 plumbers and pipefitters showed bilateral pleural thickening in 18.3% of posteroanterior chest radiographs.⁶

The present study arose from a series of meetings between the management of the United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada, Local 488, several other unions representing construction workers, the Alberta Workers Compensation Board, the Victorian Order of Nurses, the Alberta Construction Safety Association, and the research team. The members of Local 488 worked in industrial (primarily), commercial, and residential settings. Most of their work was new construction; however, most were also involved in some maintenance work, often during plant shut down. Because they worked out of the union hall and moved from site to site throughout their careers, their occupational health concerns were not the responsibility of any one employer. Given the varied nature of occupational exposures in this group, the Union was concerned that their members may have ill health related to work. The present analysis describes the lung health of the plumbers and pipefitters by comparing them with a group of local telephone workers for lung function and prevalence of respiratory symptoms and radiographic changes.

Materials and methods

IDENTIFICATION OF STUDY PARTICIPANTS

This was a cross sectional study that compared members of Local 488 who had ≥ 20 years of

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Table 1 Description of the plumbers and pipefitters and the telephone workers

	Plumbers and pipefitters (n=99)		Telephone workers (n=100)	
	n	%	n	%
Age (y):*				
38-45	20	20.2	27	27.0
46-50	23	23.2	34	34.0
51-55	27	27.3	27	27.0
≥56	29	29.3	12	12.0
Smoking category:				
Non-smokers	27	27.3	34	34.0
Ex-smokers	42	42.4	43	43.0
Current smokers	30	30.3	23	23.0
Pack-years** (mean (SD))	29.8	(18.0)	23.8	(18.6)

*p=0.015 between groups for age.

** Includes ex-smokers and current smokers.

union membership, with workers at Edmonton Telephones who had 20 years of union membership. It was thought that the construction workers with longer experience would be more likely to show adverse health effects if adverse health effects were associated with employment in that trade. The workers at Edmonton Telephones were chosen for comparison because, although they spend some of their time on construction sites, they are usually not involved when conditions are very dusty. Also, because they were represented by one of the construction unions involved in planning the study, access was facilitated.

For each of the groups, all members with ≥20 years of union membership were identified from union rosters. The number of workers initially identified was >100, the target sample size for each group. The target sample size was determined by the budget rather than by a formal calculation of sample size. Only members residing in the greater Edmonton area, and only active workers were included. For a few of the older workers it was difficult to determine whether they were between jobs or retired. Judgement was exercised in these cases. Only men <65 years of age are included in the present analysis.

Workers were selected at random from each of the lists with a table of random numbers. The plumbers and pipefitters were contacted by members of the union staff. The telephone workers were contacted by the administrative staff of Edmonton Telephones after an explanatory letter from their union. Members were selected and recruited in random order until roughly the target sample size was achieved. The response rate for the plumbers and pipefitters was 77.9%; for the telephone workers it was 72.7%. Some of the non-respondents were working outside of the Edmonton area during the time of the study. All participants gave written, informed consent. The study protocol was approved by the Research Ethics Board of the Faculty of Medicine at the University of Alberta.

The staff members who were recruiting participants were assigned specific testing days and asked to schedule workers from their group on that day. Testing days alternated for the two groups to avoid possible time related biases.

TESTING PROCEDURES

The testing took place in the offices of the Plumbers and Pipefitters' Union from February to October, 1995. Most of the testing was performed on Fridays and Saturdays to accommodate the schedules of the participants. On two occasions the testing equipment was moved to the offices of Edmonton Telephones to facilitate testing of that group.

All of the interviewing was done by a single, experienced interviewer. He was trained in the administration of the questionnaire used for the study. The questionnaire included the American Thoracic Society questionnaire on respiratory symptoms.⁷

An occupational questionnaire was developed to document the types of work environments and specific jobs worked by the participants. The work environments were divided into: (1) industrial; (2) commercial or institutional; and (3) residential. Within the industrial sector, information was obtained on specific industries common in Alberta—for example, gas and oil, forest products, etc. Within each of these industrial sectors, participants were asked to determine the amount of time spent in construction and in plant maintenance. For each category of work, the age when work started, total time spent in that type of work, and indicators of exposure to dust and fumes were requested. Exposure to dust and fumes were graded as none, slight, moderate, or severe.

Participants were also asked to list specific occupations that they had in the construction industry, how long they had worked at each job, and the average levels of dust and fumes. Information was also requested on jobs outside of their primary trade, including estimates of exposure to dust and fumes.

Spirometry was performed with a Spiromate, AS-600 spirometer according to the criteria of the American Thoracic Society.⁸ At least three forced expiratory manoeuvres were completed and the highest two forced expiratory volumes in one second (FEV_{1,s}) and forced vital capacities (FVCs) were required to be within 5% of each other. Height was measured with a ruler fixed to a wall. The tests were performed by a registered nurse with training and experience in conducting spirometric tests in occupational settings. The spirometer was calibrated at the beginning of each testing session.

Posteroanterior chest radiographs were taken at maximum inspiration, and were read independently with the International Labour Office (ILO) 1980 classification by two experienced chest physicians who were blinded to exposure histories and group membership.⁹ When these two readers disagreed on any aspect of the reading, the films were read by a third chest physician, independently of the initial readings. The final classification was the median of the individual readings.

DATA ANALYSIS

The analysis of categorical variables—for example, respiratory symptoms, radiographic changes—was conducted initially with standard contingency table techniques. Multivariate

Table 2 Comparison of prevalence of respiratory symptoms for plumbers and pipefitters and telephone workers

Symptom	Plumbers and pipefitters (n=99)		Telephone workers (n=100)		Odds ratio*	95% CI
	n	%	n	%		
Usual cough	20	20.2	9	9.0	2.60	1.05 to 6.40
Chronic cough	17	17.2	11	11.0	1.36	0.69 to 3.88
Usual phlegm	25	25.3	9	9.0	3.40	1.44 to 8.03
Chronic phlegm	21	21.2	9	9.0	2.58	1.09 to 6.13
Shortness of breath	26	26.3	15	15.0	1.66	0.79 to 3.47
Wheeze apart from colds	8	8.1	6	6.0	1.04	0.32 to 3.34
Chest tightness	33	33.7	26	26.0	1.42	0.75 to 2.66
Attacks of chest tightness	20	20.4	16	16.0	1.32	0.63 to 2.81
Attacks of wheeze with shortness of breath	16	16.2	13	13.0	1.23	0.55 to 2.76

* Odds ratios adjusted for smoking category (non, current, ex) and age (continuous variable).

analyses were performed with unconditional logistic regression techniques to calculate odds ratios (ORs) and 95% confidence intervals (95% CIs), controlled for potential confounders. Group differences in lung function were assessed with analysis of variance (ANOVA) techniques, comparing group means by smoking category (current, ex-smokers, non-smokers), controlling for age and height.

After the main analyses comparing the plumbers and pipefitters with the telephone workers for respiratory symptoms, lung function, and radiographic changes, two additional series of analyses were performed. The first set of analyses examined the time spent by the workers in various settings relative to respiratory symptoms, lung function, and radiographic changes. These groupings included: (a) forest products; (b) total time in gas and oil, including petrochemical; (c) gas and oil, construction only; (d) gas and oil, maintenance only; (e) tar sands; (f) all industrial construction; (g) all industrial maintenance; (h) commercial; (i) residential; (j) electric power; and (k) farming. Farming was the only non-trade occupation. It was included because it was reported by many of the workers (27 of the plumbers and pipefitters and 25 of the telephone workers). For respiratory symptoms and radiographic changes, the time spent in each of these settings was entered into a logistic regression model with the categorical variable—for example, usual cough, pleural plaque—as the dependent variable, and age and smoking category (non-smokers, ex-smokers, current smokers) as covariates. For lung function, time spent in each of these settings was entered into a multiple linear regression analysis with lung function as the dependent variable and age, height, and pack-years of smoking as covariates.

These analyses were repeated, multiplying the time spent in each of these settings by the

amount of self reported exposure to dust and fumes. Self reported exposure was coded as 0 (none), 1 (slight), 2 (moderate), or 3 (severe). These semiquantitative estimates were calculated separately for exposures to dust and fumes.

For the second set of analyses, union members were grouped on the basis of the occupation that they reported for the longest period (excluding supervision and office work) as pipefitters (n=57), plumbers (n=16), or welders (n=26). These were the three occupations that were recorded most often, and all of the workers had worked in at least one of these occupations. As appropriate, these workers were compared internally—that is, with each other—or individually compared with the telephone workers. There were a few other specific jobs that were listed by several of the workers, but on average for short periods.

Results

There was a significant difference in the age distribution for the plumbers and pipefitters and the telephone workers (table 1). The telephone workers had a higher percentage of their workers in the youngest age group (27%, *v* 20% for the plumbers and pipefitters), and smaller percentages of workers in the highest age group (12% for the telephone workers and 29% for the plumbers and pipefitters). The youngest age recorded was 38, owing to the fact that workers had to have at least 20 years of service to be included in the study.

Smoking habits did not differ significantly for the two groups (table 1). However, it can be seen that there were more non-smokers among the telephone workers than among the plumbers and pipefitters. Also, among current and ex-smokers, there was no significant difference in the average total amount smoked.

Respiratory symptoms were more commonly reported by plumbers and pipefitters than telephone workers (table 2). Odds ratios for all of the respiratory symptoms were >1. These comparisons were adjusted for age and smoking. Significantly increased ORs were found for usual cough, usual phlegm, and chronic phlegm (defined as phlegm for ≥3 months a year for the previous two years).

The two groups were comparable for a history of most respiratory conditions (table 3). The plumbers and pipefitters were significantly less likely than the telephone workers to report a history of lung trouble before the age of 16.

Table 3 Comparison of history of respiratory conditions for plumbers and pipefitters and telephone workers

Symptom	Plumbers and pipefitters (n=99)		Telephone workers (n=100)		Odds ratio*	95% CI
	n	%	n	%		
Serious chest illness	9	9.1	6	6.0	1.55	0.52 to 4.61
Lung trouble before age 16	3	3.0	12	12.0	0.24	0.07 to 0.91
Bronchitis	23	23.2	22	22.0	1.23	0.62 to 2.46
Pneumonia	27	27.6	27	27.0	1.05	0.55 to 2.00
Asthma	5	5.1	5	5.0	1.07	0.30 to 3.87

* Odds ratios adjusted for smoking category (non, current, ex) and age (continuous variable).

Table 4 Lung function results for plumbers and pipefitters and telephone workers*

Measurement	Plumbers and pipefitters	Telephone workers	p Value
FEV ₁ (l)			
Non-smokers	3.54	3.79	0.055
Ex-smokers	3.60	3.95	
Current smokers	3.61	3.57	
FVC (l)			
Non-smokers	4.41	4.84	0.038
Ex-smokers	4.64	5.13	
Current smokers	4.78	4.70	
FEV ₁ /FVC (%)			
Non-smokers	77.2	76.8	0.97
Ex-smokers	77.8	77.0	
Current smokers	75.4	76.8	
FEF ₂₅₋₇₅ (l/s)			
Non-smokers	3.50	3.72	0.29
Ex-smokers	3.39	3.56	
Current smokers	3.10	3.22	
FEF ₅₀ (l/s)			
Non-smokers	4.49	4.82	0.25
Ex-smokers	4.31	4.65	
Current smokers	4.05	4.12	
FEF ₇₅ (l/s)			
Non-smokers	1.37	1.51	0.17
Ex-smokers	1.31	1.33	
Current smokers	1.12	1.28	
Peak expiratory flow (l/s)			
Non-smokers	8.14	8.33	0.24
Ex-smokers	8.20	9.10	
Current smokers	8.16	8.24	

* Mean values adjusted for age and height.

In general, the lung function results for the plumbers and pipefitters and the telephone workers were comparable, however, there were some exceptions (table 4). Average values for FEV₁ were lower for the plumbers and pipefitters than for the telephone workers for all but the current smokers. The overall difference was not significant.

There was a significant difference between the plumbers and pipefitters and the telephone workers for FVC. Deficits among the plumbers and pipefitters were limited to non-smokers and ex-smokers. The effect of smoking category on lung function was evident for most lung function indicators.

Twenty per cent of the radiographs of the plumbers and pipefitters showed some pleural or parenchymal abnormality, compared with only 2.1% of the radiographs of the telephone workers. The differences between groups were significant for pleural plaques and for diffuse pleural thickening, with ORs near 10 (table 5). Bilateral pleural thickening (as defined by Sprince *et al*⁶) was found in 4.4% of plumbers and pipefitters and none of the telephone workers. Bilateral pleural change (including pleural plaques, diffuse pleural thickening, pleural calcification, blunting of the costophrenic angle, and diaphragmatic thickening)

was found in 7.8% of the plumbers and pipefitters and 1% of the telephone workers.

When the indicators of lung health were compared with the amount of time spent working in various settings within the industry, several significant results were obtained. The number of significant findings did not exceed the number that would have been expected by chance. The amount of time spent working in the residential (housing) sector was associated with presence of any radiographic abnormality (OR for one year of residential work was 1.41, 95% CI 1.11 to 1.80) and pleural plaques (OR 1.09, 95% CI 1.01 to 1.18). A year of residential work was also associated with a significant deficit in the FEV₁/FVC of 1.06%, and in the forced expiratory flow between 25% and 75% FVC (FEF₂₅₋₇₅) of 0.105 l/s. Usual cough was also related to the amount of time spent in residential work. There were 42 workers who worked in residential settings for an average of just over 3.5 years. Again, given the many comparisons, these findings could easily have arisen by chance.

Similarly, when time spent in each industrial setting was weighted by self reported exposure to dust and fumes, the number of significant associations did not exceed the number expected by chance. The OR for one year of residential work at moderate dust and any radiographic abnormality was 1.53 (95% CI 1.10 to 2.14). There were no significant associations between dust or fume weighted exposure in any industrial setting and any of the lung function variables.

When the workers were divided according to whether their longest service was as a pipefitter, plumber, or welder, there were no significant differences in lung function among groups. The prevalence of radiographic signs did, however, differ among groups (table 6). When the three groups were cross classified by presence or absence of radiographic signs, significant differences were found for pleural plaques, bilateral pleural thickening, bilateral pleural change, and any abnormality. For each of these categories, those who spent the largest proportion of their time as plumbers had the highest prevalence. The pipefitters generally had the lowest prevalence of radiographic signs. The average ages for the three groups were 50.8 (pipefitters), 54.6 (plumbers), and 52.9 (welders). These differences were not significant.

Table 5 Radiographic findings for plumbers and pipefitters and telephone workers

Finding	Plumbers and pipefitters (n=99)		Telephone workers (n=100)		Odds ratio	95% CI
	n	%	n	%		
Pleural thickening:						
Circumscribed	9	10.0	1	1.0	10.67	1.32 to 85.98
Diffuse	8	8.9	1	1.0	9.37	1.15 to 76.46
Diaphragm	3	3.3	1	1.0	3.31	0.34 to 32.42
Blunting of costophrenic angle	4	4.4	1	1.0	4.47	0.49 to 40.72
Pleural calcification	5	5.6	1	1.0	5.65	0.65 to 49.30
Bilateral pleural thickening	4	4.4	0	—	—	—
Bilateral pleural change	7	7.8	1	1.0	8.10	0.97 to 68.75
Small opacities	0	—	1	1.0	—	—
Any abnormality	18	20.0	2	2.1	11.88	2.67 to 52.83

Table 6 Comparison of radiographic signs for pipefitters, plumbers, and welders, classified by occupation with longest service

Finding	Pipefitters		Plumbers		Welders		p Value
	n	%	n	%	n	%	
Total	52		14		24		
Pleural thickening:							
Circumscribed	2	3.8	4	28.6	3	12.5	0.035
Diffuse	4	7.7	3	21.4	1	4.2	0.23
Diaphragm	3	5.8	0	—	0	—	0.32
Blunting of costophrenic angle	1	1.9	2	14.3	1	4.1	0.22
Pleural calcification	3	5.8	0	—	2	8.3	0.38
Bilateral pleural thickening	0	—	2	14.3	2	8.3	0.039
Bilateral pleural change	1	1.9	4	28.6	2	8.3	0.0042
Any abnormality	6	11.5	8	57.1	4	16.7	0.0023

Table 7 Comparison of cough and phlegm for pipefitters, plumbers, and welders, classified by occupation with longest service

Finding	Overall* p Value	Pipefitters		Plumbers		Welders	
		OR	p Value	OR	p Value	OR	p Value
Usual cough	0.038	3.08	0.024	4.93	0.034	0.80	0.797
Usual phlegm	0.036	3.60	0.007	4.56	0.038	2.52	0.146
Chronic cough	0.566	1.70	0.279	2.34	0.267	1.03	0.965
Chronic phlegm	0.195	2.66	0.042	2.62	0.210	2.39	0.164

* Significance of set of indicator variables for occupation in multivariate model, controlled for smoking category (non, current, ex) and age (continuous variable).

When prevalence of respiratory symptoms for each subgroup of workers was compared with the telephone workers, usual cough and usual phlegm were significantly associated with work classification (table 7). Significantly increased ORs were found for usual cough and usual phlegm for both the pipefitters and the plumbers, but not for the welders. Although the work classification variable was not significantly associated with chronic phlegm (overall), the OR for pipefitters was significantly increased. The ORs for chronic phlegm were similar for all three groups.

Discussion

As with any cross sectional study, there is a danger that the workers most affected by the work environment would have left the occupation before the start of the study and would not be included. It was thought that the chronic effects of work exposures would be best evaluated in long term workers. However, it should be noted that the results are generalisable only to active, long term workers and that the study did not include those who retired due to disability or superannuation.

The sample size was limited and negated the possibility of assessing subtle effects. This was especially important in evaluating group differences in radiographic changes. Very few abnormalities were found among the telephone workers, making risk estimates unstable.

None of the readers were certified by the National Institute for Occupational Safety and Health as B readers. However, all had extensive experience in chest radiography and the two primary readers had used the ILO classification system for many years.

There was an excess of respiratory symptoms suggestive of irritant exposures in the plumbers and pipefitters. Cough and phlegm are generally related to smoking, but can be associated with exposures to dust and fumes.^{10 11} Because these analyses were adjusted for the effects of

smoking, the difference in cough and phlegm may be due to exposures on the worksite. However, it is not possible to say this with certainty. The pattern of excess of respiratory symptoms was not suggestive of bronchial hyperresponsiveness. Those workers who spent the highest proportion of their careers as pipefitters and plumbers showed significant excesses of usual cough and phlegm. Those whose highest proportion of time was spent as welders did not show significant increases in prevalence of cough and phlegm compared with the telephone workers, although the OR for usual phlegm was 2.52. Odds ratios for chronic phlegm were high for all subgroups, but only for the pipefitters was the difference significant.

Recent studies^{12 13} and a review¹⁴ have reported an excess of cough and phlegm in welders in the absence of symptoms suggestive of bronchial hyperresponsiveness. There is also some evidence of transient changes in lung function in welders tested across the workshift.^{15 16}

The present study did not examine changes in lung function and respiratory symptoms across the workshift. The welders did not show an excess of cough relative to the telephone workers. They did, however, show increased ORs for phlegm and chronic phlegm that were not significant.

There was a significant difference in the FVC between the two groups. However, this did not hold for all smoking categories. The FVC was lower in the plumbers and pipefitters for non-smokers and ex-smokers, but was slightly higher for smokers. Concern about possible exposures to asbestos and its usual effect on the FVC make this result interesting but inconclusive. When workers with any radiographic abnormality were excluded from the analysis, average lung function values were generally greater for each smoking category and none of the differences between the

plumbers and pipefitters and the telephone workers were significant. Lung function was not found to vary among the groups of workers when they were classified as pipefitters, plumbers, or welders, on the basis of duration of service.

The effect of smoking on lung function is noteworthy. These results can be used by the union in their health education efforts.

The virtual absence of small parenchymal opacities was contrary to reports from unexposed populations.^{17,18} Sprince *et al*⁶ found 7.8% of plumbers and pipefitters to have irregular opacities. Further, the prevalence of bilateral pleural thickening among the plumbers and pipefitters in the present study (4.4%) was less than a quarter of that found by Sprince *et al*.⁶ The plumbers and pipefitters in the present study were older than those studied by Sprince *et al*.⁶ The response rate reported by Sprince *et al* was also lower (51% among active workers and 21% among retired workers) than in the present study (78% of active workers). Also, Sprince *et al*⁶ used a single B reader, whereas we used three readers. The study by Sprince *et al*⁶ lacked a comparison group that would have made it possible to compare relative differences between plumbers and pipefitters and non-exposed workers.

Indicators of lung health did not vary markedly by time spent in various work settings. The data relating to time spent in residential construction are worthy of mention, but are inconclusive given the many comparisons between health outcomes and sub-divisions of the work histories.

The present study and previous studies provide evidence that plumbers and pipefitters are exposed to asbestos. The morbidity study of Sprince *et al*⁶ showed evidence of asbestos exposure in plumbers and pipefitters, as has been discussed already. Robinson *et al*³ found a proportional mortality ratio of 1097 for asbestosis among plumbers, based on eight observed cases. Teta *et al*⁴ found an OR of 3.87 for mesothelioma for plumbers and pipefitters, although based on few cases and incomplete work histories.

Declines in lung health often represent slow processes. Adverse changes can be caused by occupational, non-occupational, and genetic factors. In many industries, workers with the exposures experienced by plumbers and pipefitters are screened on a regular basis. Because the workers in the present study worked in various settings throughout their careers, they

were not evaluated for changes in these health indicators. Appropriate screening of this and other similar workforces would require the involvement of medical personnel with expertise in the evaluation of occupational diseases and the provision of opportunities for workers to be screened on a regular basis. This is not currently happening in Canada despite universal health care, nor can the existing medical care system provide the required expertise and administrative structure. Because the unions generally represent a regular contact point for these workers, their involvement in these screening programmes would be essential.

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