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SUMMARY

INTRODUCTION

In an effort to increase knowledge on background values of cadmium excretion in the Norwegian population, the Norwegian Institute for Air Research in cooperation with the Institute of Occupational Health measured urinary cadmium concentrations in the inhabitants of Holmestrand, Sørumsand, and Oslo-Nydalen in the Spring of 1984. The study was in conjunction with a study on the concentrations of lead in blood under different ambient exposure conditions. The three sites were chosen because of the known differences in air lead concentration. Until 1984, Holmestrand has had a major traffic artery through the town but has no industrial sources of either lead or cadmium. Sørumsand was considered a control town having no industrial sources of lead or cadmium and relatively little traffic. In the Oslo-Nydalen area lies a major traffic artery, and an industrial source of both lead and cadmium.

METHODOLOGY

The study was conducted at three sites:

1) Oslo-Nydalen - a part of Oslo traversed by a major throughway (ca. 30 000 vehicles daily) and having two point sources of emissions of industrial lead and one of cadmium.

2) Holmestrand - a town traversed by a major throughway (in 1983, 11 000 vehicles daily were registered as crossing through the town) that in 1984 became relatively free for traffic when a tunnel opened that allowed traffic to bypass the city. Holmestrand has no known industrial sources of airborne lead or cadmium.

3) Sørumsand - a small town having very little traffic (at the time of measurement estimated at 3 000 cars daily) and no industrial sources of airborne lead or cadmium.

The study was designed such that for each individual a specific urinary cadmium concentration was related to an estimate of that individual´s recent exposure to ambient cadmium during the two weeks immediately prior to urine sampling. In addition, a set of other sociobiological parameters (e.g. smoking, age, sex, etc.) was noted.

In Oslo-Nydalen, 470 people (ranging in age from 2 to 98 years; 182 children; 129 men; and 159 women) volunteered for the study. In Sørumsand, 107 (ranging in age from 3 to 91; 24 children; 28 men; and 55 women) and in Holmestrand 149 (ranging in age from 3 to 92; 21 children; 48 men; and 80 women) volunteered for the study.

Individual ambient cadmium exposure was estimated by combining information from diaries of weekly patterns of activity (hours per day for each day of the week spent in each of several microenvironments such as indoor at home or outdoors at school) with both measured and estimated ambient cadmium concentrations. These estimates included indoor cadmium levels resulting from cigarette smoking. Urinary cadmium levels for each individual was measured by electrothermal atomic absorption spectroscopy. Urinary creatinine was also measured in order to allow standardizing urinary cadmium for urinary concentration.

In addition, the hematologic variables hemoglobin, hematocrit and mean cell hemoglobin concentration were measured. The questionnaire included information on: 1) additional cadmium exposure via hobbies, occupation, and smoking (both active and passive), and 2) other sociobiologic parameters such as alcohol consumption, use of vitamins and iron supplements, etc. that could influence metabolism.

RESULTS

1) Concentrations of cadmium in air in Oslo-Nydalen were 2 to 3 times higher than those measured in either Holmestrand or Sørumsand, and most probably were of industrial origin. Holmestrand and Sørumsand had equal levels of ambient cadmium both in 1983 and in 1984. Values in 1984, although low, were 2 to 3 times higher than those measured in 1983.

2) Values of cadmium in outdoor dust measured in Holmestrand and Sørumsand in 1983 and 1984 did not follow the same patterns as those measured in air. Values of cadmium in dust were 2 to 3 times higher in Holmestrand than Sørumsand, especially noticeable in the water soluble fraction and were higher in 1983 than 1984.

3) There were no measurable amounts of cadmium in drinking water.

4) In an attempt to describe those parameters that seemingly influence urinary cadmium, socio-biologic variables and ambient cadmium exposure were entered into an analysis of variance with covariance that gave the following results:

Children: Urinary cadmium concentrations were not significantly related to sex, age, passive smoking, social class or ambient cadmium.

Adults: Concentrations of urinary cadmium: 1) were higher in adult women than men, 2) increased with age, 3) decreased with increased alcohol consumption, 4) were higher in current and previous smokers, and 5) were higher in Holmestrand than in Oslo or Sørumsand.

5) A step-wise multiple regression analysis was also performed on the data that essentially confirmed the findings found using the analysis of variance with covariance. In children, however, there were significantly higher values in Holmestrand, a finding that was not confirmed in adults.

6) Cadmium has been shown to influence the hematopoietic system, including hemoglobin, hematocrit, mean cell hemoglobin concentration and zinc protoporphyrin. These variables are better known as effect variables of lead ingestion and were therefore incorporated into the design of the primary lead study. Analysis of the results using analysis of variance with covariance where the natural logarithm of urinary cadmium/urinary creatinine is entered as a covariate gave the following results:

Children: LogU-Cd/U-Cr had a significant negative correlation to hemoglobin, mean cell hemoglobin concentration and the natural logarithm of zinc protoporphyrin, but not to hematocrit.

Adult : LogU-Cd/U-Cr had a significant negative correlation to hemoglobin and mean cell hemoglobin concentration, but not to hematocrit or the natural logarithm of zinc protoporphyrin.

DISCUSSION

Measured concentrations of cadmium in urine in the Norwegian population seem similar to those values measured in Sweden and the U.S.A. and lower than those measured in high exposure areas in Japan. The concentrations of ambient cadmium in the three geographic areas within Norway, Oslo-Nydalen, Holmestrand and Sørumsand were not high enough to impact concentrations of cadmium in urine directly through inhalation. Suggested geographical differences (higher concentrations in Holmestrand) may reflect differences in exposure to other, e.g. nutritional sources. However, these other sources can, themselves reflect an indirect exposure to ambient cadmium via nutrient chains, etc.

Women have significantly higher values than men of urinary cadmium/urinary creatinine in this study, a finding that is also indicated in the Swedish and the Japanese data. Sexual differences in creatinine excretion can possibly explain these findings.

The significant increase of urinary cadmium with increased smoking is a well known finding and reflects the relatively high amounts of cadmium in cigarettes. Passive smoking in this study did not seem to measurably influence urinary cadmium concentrations in either children or adults.

The significant increase of urinary cadmium with age is likewise a well known finding that represents the gradual accumulation of cadmium in the kidneys over a lifetime.

The significant negative correlation between alcohol consumption and urinary cadmium has not previously been reported. This relationship indicates that alcohol consumption can affect uptake or exretion of cadmium or metabolism of cadmium either in the liver or kidneys. One cannot rule out, however, that alcohol consumption is closely correlated to another unmeasured parameter that is the true connection to urinary cadmium concentrations.

The possibility that urinary cadmium, even at these low levels may be an indicator of a negative effect on the hematopoietic (reduced incorporation of iron into the red blood cells) system is disturbing and should be further investigated.

SAMMENDRAG

INNLEDNING

Våren 1984 gjennomførte Norsk institutt for luftforskning i samarbeid med Forskningssenteret AMY (tidligere Yrkeshygienisk Institutt) en undersøkelse av kadmiumkonsentrasjoner i urin hos beboere i Nydalen i Oslo, Holmestrand og Sørumsand. Prosjektet var nært knyttet til en undersøkelse av blykonsentrasjoner i blodet hos beboerne i disse tre områdene. Områdene ble valgt pga kjente forskjeller i blykonsentrasjoner i luft. Hensikten var å kartlegge referanseverdier for utskillelse av kadmium i urin i befolkningsgrupper sammenlignet med luftverdiene. Holmestrand var sterkt trafikkbelastet fram til 1984, men har ingen industrielle kilder til bly eller kadmium. Sørumsand er et lavt belastet kontrollområde med liten trafikk og ingen industrielle kilder til disse tungmetallene. Nydalen er sterkt trafikkbelastet og har en industriell kilde til både bly og kadmium.

METODIKK

Undersøkelsen ble utført på tre lokaliteter:

1) Nydalen i Oslo - En bydel med en stor trafikkåre (Store Ringvei - ca 30 000 kjøretøyer i døgnet). I området ligger også en industribedrift med utslipp av bly og kadmium.

2) Holmestrand - Et tettsted som inntil 1984 var gjennomskåret av en stor trafikkåre (E18 - ca 11 000 kjøretøyer i døgnet). I 1984 åpnet en tunnel som ledet trafikken utenom tettstedet. Holmestrand har ingen kjente industrielle kilder til bly eller kadmium.

3) Sørumsand - Et tettsted med liten trafikk (ca 3 000 kjøretøyer i døgnet) og ingen industrielle kilder til bly eller kadmium.

I undersøkelsen ble hver enkelt deltagers konsentrasjon av kadmium i urin sammenholdt med en beregnet eksponering for kadmium i luft de siste to ukene før urinprøven ble avgitt.

I Nydalen var 470 personer av begge kjønn og i alle aldre med på undersøkelsen (182 barn, 129 menn og 159 kvinner). I Holmestrand meldte 149 deltagere seg (21 barn, 48 menn og 80 kvinner), og i Sørumsand deltok 107 personer (24 barn, 28 menn og 55 kvinner).

Hver deltager besvarte et skjema med spørsmål om aktiviteter og aktivitetsmønstre de to siste ukene før urinprøven. Denne informasjonen, sammen med både målte og estimerte nivåer av kadmiumkonsentrasjoner i ute- og inne-luft (inkludert røykfylte innemiljøer), dannet grunnlaget for beregninger av den individuelle eksponeringen for kadmium i luft. Kadmiuminnholdet i urin ble målt ved hjelp av atomabsorpsjonspektrometri. Kreatinin i urin ble målt for å justere kadmiuminnholdet for urinkonsentrasjonen.

I tillegg ble blodparametrene hemoglobin, hematokrit og gjennomsnittlig blodcelle-hemoglobinkonsentrasjon (MCHC) målt. Spørreskjemaet gav også informasjon om annen eksponering for kadmium gjennom arbeid, hobbyer, røyking (både aktiv og passiv). I tillegg ble andre sosiobiologiske parametre, som f.eks. alkoholforbruk, som kan ha betydning for stofforandring i kroppen og inntak av vitaminer og jerntilskudd registrert.

RESULTATER

1) Konsentrasjoner av kadmium i luft i Nydalen var to til tre ganger høyere enn i Holmestrand og Sørumsand og skyldtes hovedsakelig industriutslipp. Stasjonene i Holmestrand og Sørumsand viste samme konsentrasjoner, men verdiene var to til tre ganger høyere i 1984 enn i 1983. Begge steder må imidlertid konsentrasjonene sies å være lave.

2) Kadmiumkonsentrasjoner i nedfallsstøv i Holmestrand og Sørumsand i 1983 og 1984 viste ikke det samme mønster som nivåene i luft; (svevestøv). Den vannløselige delen av støvfallet i Holmestrand inneholdt to til tre ganger mer kadmium enn i Sørumsand og var høyere i 1983 enn i 1984.

3) I drikkevann ble det ikke målt kadmiumkonsentrasjoner over deteksjonsgrensen.

4) For å beskrive parametre som påvirker kadmiumkonsentrasjoner i urin ble det gjort en variansanalyse med kovarians av de sosiobiologiske variablene og eksponering for kadmium i luft hvor det framkom følgende resultater:

Barn: Konsentrasjon av kadmium i urin viste ingen signifikant sammenheng med verken kjønn, alder, passiv røyking eller eksponering for kadmium.

Voksne: Kvinner hadde høyere innhold av kadmium i urin enn menn. Kadmiumkonsentrasjonen i urin økte med alderen. Konsentrasjonen gikk ned med økt alkoholforbruk. Røyking økte nivået av kadmium i urin, og verdiene i Holmestrand var høyere enn i Nydalen og Sørumsand.

5) Multipel trinnvis regresjonsanalyse viste hovedsakelig samme resultater som ovenfor. I Holmestrand ble det imidlertid funnet høyere verdier blant barn, men ikke blant voksne.

6) Når konsentrasjonen av kadmium i urin blir tilstrekkelig høy kan dette virke inn på produksjon av røde blodceller. Dette gir utslag i variabler som hemoglobin, hematokrit og sink protoporphyrin. Anemi har også vært påvist med økt eksponering for kadmium. På grunn av en lignende effekt av eksponering for bly, ble disse variablene målt i denne undersøkelsen. Analyse av varians med kovarians hvor den naturlige logaritmen av U-Cd/U-Kr i urin er tatt inn som kovariant, gav følgende resultat:

Barn: LogU-Cd/U-Kr hadde en signifikant negativ sammenheng med hemoglobin og derav av gjennomsnittlig hemoglobinkonsentrasjon i røde blodlegemer, og med den naturlige logaritmen av sink protoporphyrin, men ikke med hematokrit.

Voksne: LogU-Cd/U-KR hadde en signifikant negativ sammenheng med hemoglobin og gjennomsnittlig hemoglobinkonsentrasjon i røde blodlegemer, men ikke med hematokrit eller den naturlige logaritmen av sink protoporphyrin.

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DISKUSJON

Nivåene av kadmium i urin målt i den norske befolkningen er sammenlignbare med nivåene i Sverige og U.S.A., men er lavere enn de i høyt belastede områder i Japan. Konsentrasjonene av kadmium i luft i tre geografiske områder i Norge, Nydalen i Oslo, Holmestrand og Sørumsand, var ikke høye nok til å påvirke nivået av kadmium i urin gjennom direkte inhalasjon. Forskjellen mellom stedene må derfor skyldes andre kilder, som f. eks. ernæring. Det kan imidlertid ikke utelukkes at disse andre kildene kan gi en indirekte påvirkning av kadmium i luft gjennom næringskjeder.

Undersøkelsen viste at kvinner har høyere verdier av kadmium i urin enn menn. Denne forskjellen er signifikant. Det samme er også funnet i svenske og japanske undersøkelser. Dette kan delvis forklares ved at kreatinin-utskillelsen er lavere hos kvinner.

At kadmium i urin øker med økt røyking er ikke noe nytt. Dette forklares ved at sigarettrøyk innholder relativt mye kadmium. Passiv røyking viste ingen signifikant sammenheng med kadmium i urin, verken hos barn eller voksne.

Kadmium samles opp i nyrene i løpet av livet og derfor øker utskillelsen av urin med økende alder.

Signifikant negativ korrelasjon mellom alkoholforbruk og kadmium i urin er ikke tidligere rapportert. Dette antyder at alkoholinntak kan påvirke opptak og utskillelse av kadmium eller metabolisme av kadmium enten i leveren eller nyrene. En kan imidlertid ikke se bort fra at alkoholforbruk kan være relatert til en annen ikke registrert parameter som kan påvirke kadmiumutskillelsen i urin.

Indikasjonen på at kadmium i urin på disse lave nivåer påvirker bloddannelsen (det hematopoietiske systemet) på en negativ måte burde studeres nærmere.

FOREWORD

This report summarizes an investigation done in 1984 by the Norwegian Institute of Air Research (NILU) in collaboration with the National Institute of Occupational Health and City Health Department, Oslo, of urinary cadmium concentrations in the inhabitants of the Nydalen area in Oslo, Holmestrand and Sørumsand.

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CADMIUM IN URINE IN INHABITANTS OF OSLO-NYDALEN, HOLMESTRAND AND SØRUMSAND AS A FUNCTION OF AIR CADMIUM AND OTHER SOCIO-ECONOMIC FACTORS

1 INTRODUCTION

Although much information is available on cadmium concentrations in the urine of occupationally exposed individuals, very little background information is available on typical concentrations of cadmium in urine in the general population of Norway. Thus in 1984, the Norwegian Institute for Air Research in cooperation with the National Institute of Occupational Health and the City Health Department, Oslo decided to expand an investigation of blood lead concentrations in three populations to include urinary and ambient cadmium.

Although there has been much recent discussion in the literature of the influence of inhalation of air lead on the concentrations of lead in blood in humans, it is generally accepted that body stores of cadmium originate primarily from nutritional sources. However, nutritional sources can be considered to reflect indirect exposure to ambient cadmium pollution. Cadmium builds up slowly in the kidneys of exposed individuals over a lifetime, therefore urinary cadmium reflects primarily long-term exposure, not recent exposure.

Urinary cadmium excretion was measured in the inhabitants of three areas originally chosen for their air lead concentrations: Oslo-Nydalen, where lead is released into the air by two industrial sources and cadmium by one; Holmestrand, a town that had been exposed to relatively high traffic up to 1984, but that was currently free for through-traffic after the opening of an alternate route that by-passes the town (vehicular exhaust however, is not considered a source of cadmium); Sørumsand, having no industrial sources of lead or cadmium and low throughtraffic. It was therefore possible to compare populations that: 1) had been exposed only to low concentrations of ambient lead or cadmium, 2) had been exposed to relatively high concentrations

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of ambient lead but not cadmium, and 3) had been exposed to relatively high ambient concentrations of lead and moderate cadmium. (Clench-Aas et al., 1984, 1986).

In the original investigation of blood lead concentrations, individual air lead exposure was estimated by combining information from a diary of weekly patterns of activity with both measured and estimated ambient lead concentrations. Since ambient cadmium was measured simultaneously, it was possible to use the same method (computer modelling) to estimate exposure over the two previous weeks to urine sampling. This exposure estimate reflects recent exposure to cadmium in air but can be considered to be fairly representative of long-term exposure also. The study also took into account such confounding factors as age, sex, socio-economic status, smoking habits (both active and passive), exposure to cadmium contaminated hobbies, (e.g. painting etc.) and occupational exposure.

2 MATERIALS AND METHODS

2.1 OVERVIEW

This study combined information from three main sources

1) self-administered questionnaires
2) measurements of ambient cadmium (both indoor and outdoor)
3) urinary cadmium

Combining these three sources of information enabled estimating individual air cadmium exposure; controlling for confounding factors such as age, sex, social class, smoking habits, and alcohol consumption; and studying the correlation of urinary cadmium to air cadmium concentrations. Further details can be found in the original lead studies (Clench-Aas et al., 1984,1986).

2.2 CHOICE OF SITES

The investigation took place at three sites (Figures 1, 2 and 3): Oslo-Nydalen, Holmestrand, and Sørumsand:

1) Oslo-Nydalen - a part of Oslo traversed by a major throughway (ca. 30 000 vehicles daily) and having one point source of industrial cadmium emissions.

2) Holmestrand - a town previously (up to 1984) traversed by a major throughway (around 11 000 vehicles daily). The recent opening of a tunnel causes the throughway to bypass the town which is thus currently free for most of the traffic. Holmestrand has no known industrial sources of cadmium.

3) Sørumsand - a small town having very little traffic (between 2 500 and 3 000 cars daily) and no known industrial sources of airborne cadmium.

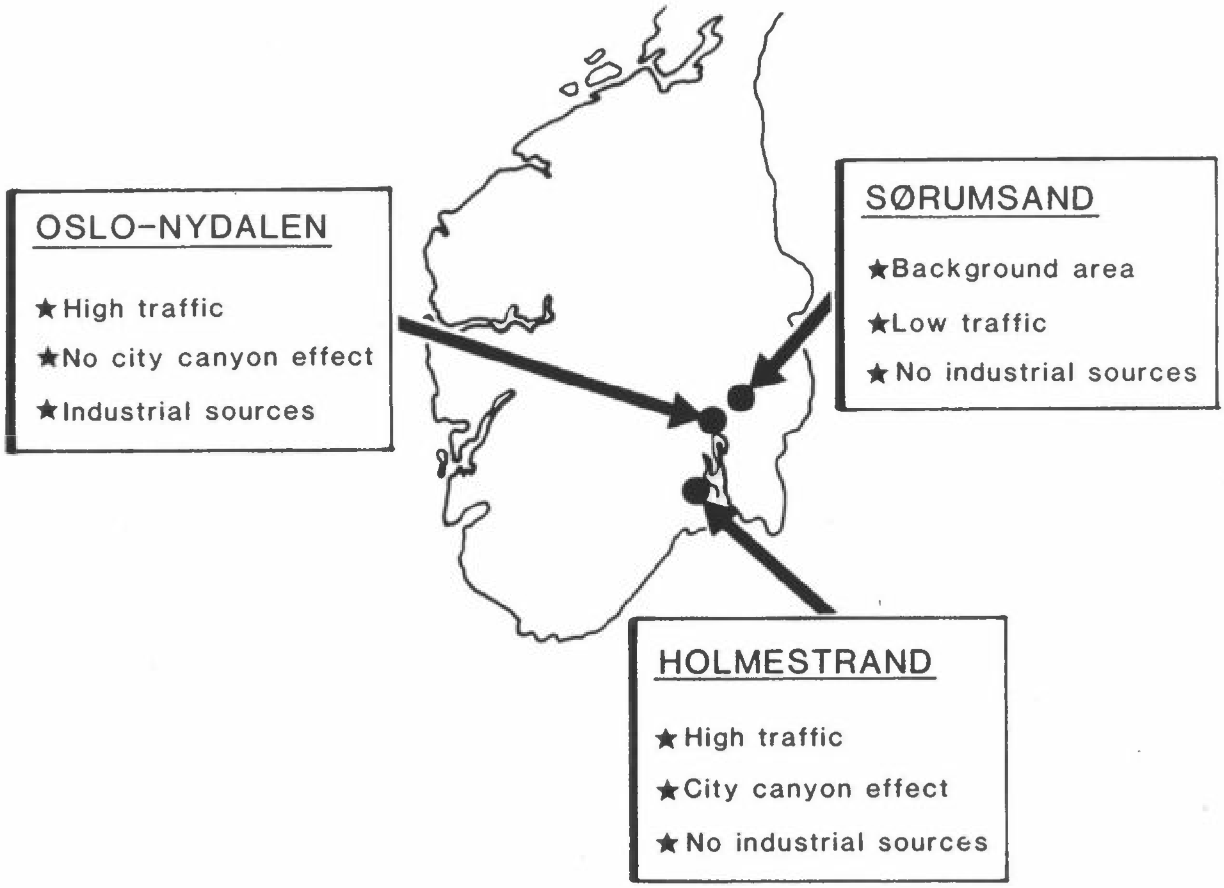

Figure 1: Overview of the characteristics of the three site locations used in the study.

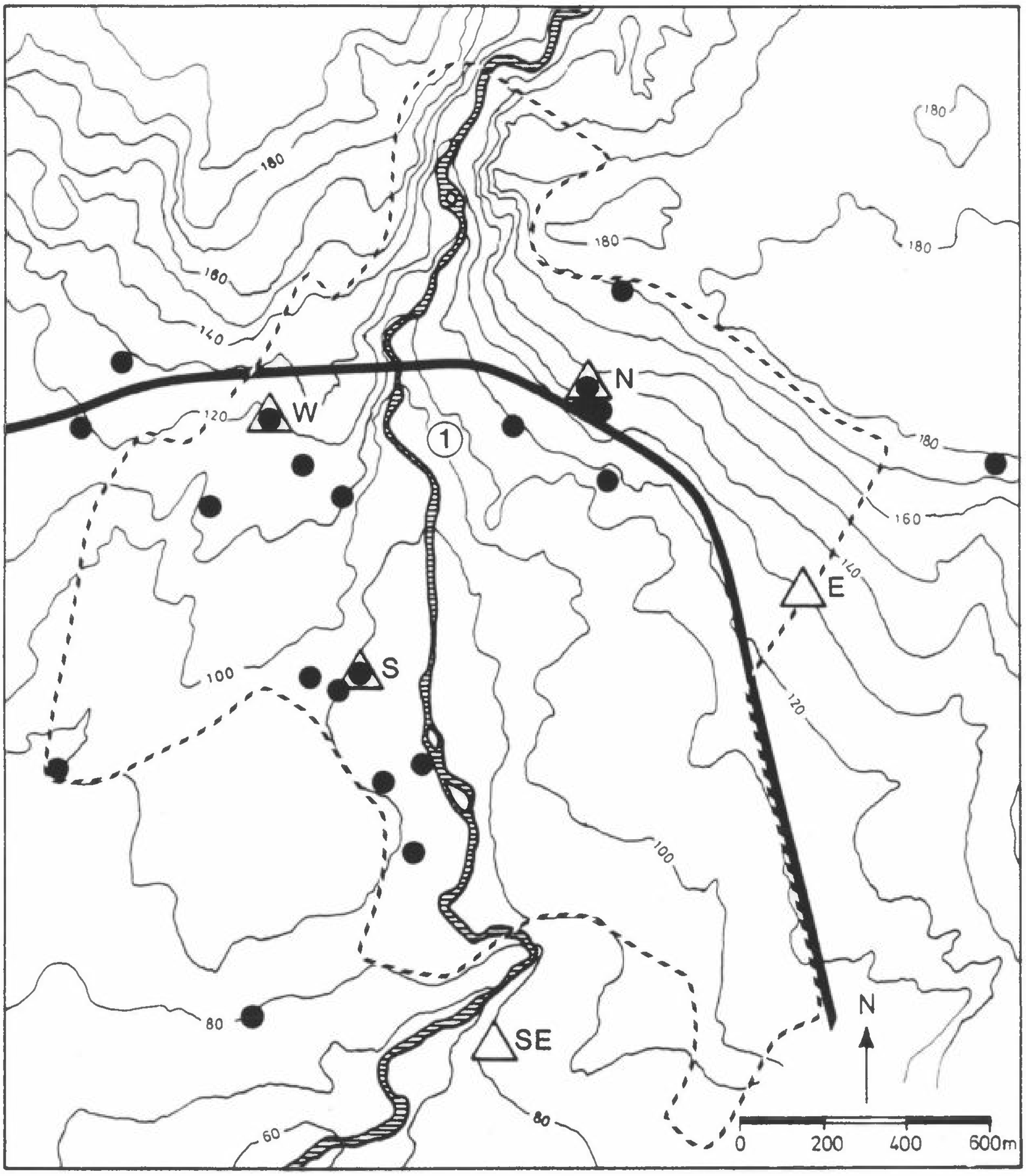

Figure 2: Topographical map of the study area, Oslo-Nydalen
△ outdoor air cadmium stations
● indoor air cadmium stations
Additional outdoor stations were operating in downtown Oslo as well. ① Point industrial cadmium source;
▬ Highway 160 with ca 30 000 vehicles daily;
- - - geographical limits within which volunteers lived.

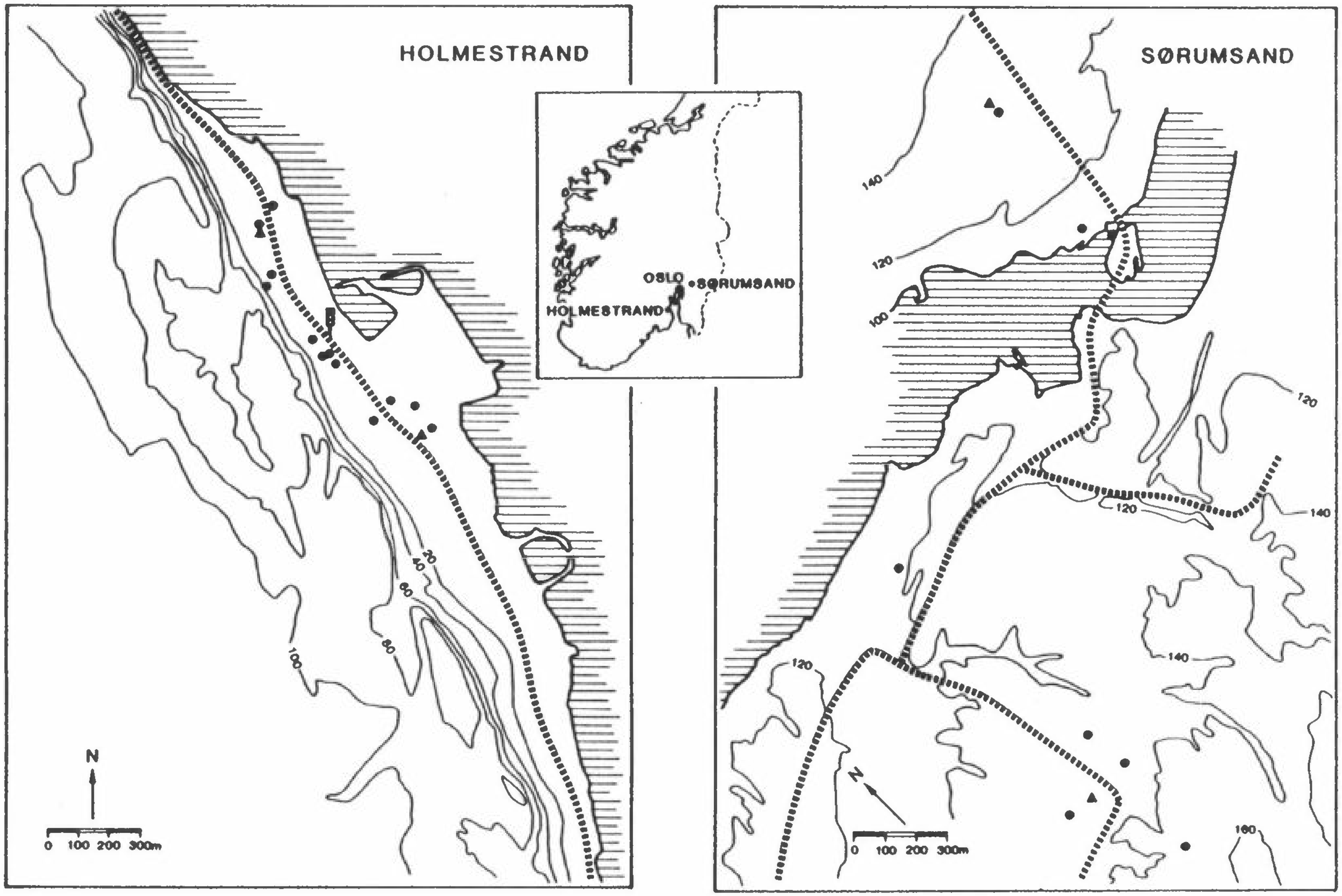

Figure 3: Topographic maps of the two study towns, Holmestrand and Sørumsand.
▲ outdoor air cadmium stations
● indoor cadmium stations

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2.3 CHOICE OF SUBJECTS

2.3.1 Subject selection

Oslo-Nydalen

The intention in the Oslo study, was to maximize participation of children. The local schools provided lists of all children living in the chosen study area.

Families were contacted by mail and requested to participate as a family. A first recruiting letter was sent to 454 families. Of these 94 (21%) responded to the first letter. A second reminder letter, was sent to the remaining 360 families who had not answered during the first round. Of these 104 (28%) answered. Of the total 198 (44%) families answering the first or second reminders, 166 (37%) said yes, that they would be willing and 32 (7%) no, that they were not willing to participate.

In addition, three pre-school facilities in the area were contacted and three clinics for the elderly (sykehjem).

The total number of participants was 470.

As is typical for this kind of study, one cannot say the selection was random. It was, of course, based on voluntary participation. One becomes aware most notably of a prevalence of people in the health fields, people possibly more interested in their own health (heavy joggers and so forth) and to the contrary people having been quite sick and therefore used to blood sampling. There was a noticeable lack of families employed in the local industries despite local industrial support of the study.

Holmestrand

Individuals were selected in 1983 for the original study on blood lead levels in the population before the tunnel opened. Therefore, criteria for subject selection was that the individual either lived or worked near the main road. Efforts were made to include as many children as possible, therefore, all children and their families living under the plateau were contacted. In 1984, all individuals who participated in 1983 were recontacted and asked to participate again after the tunnel had opened. They were also asked to give a morning urine sample of cadmium measurements. Of the original population sample, 84% participated in 1984.

Sørumsand

Subject selection in Sørumsand involved sending letters to families with children living near the outdoor samplers. As in Holmestrand, the sample population was first recruited in 1983, in connection with the first study. In 1984, 86% of the original population, took part.

2.3.2 Population characteristics

A total of 470 individuals volunteered for the study from Oslo-Nydalen: 182 children (105 boys and 77 girls); and 288 adults (129 men and 159 women). In Holmestrand, 149 volunteered for the study: 21 children (10 boys, and 11 girls); and 128 adults (48 men and 80 women). The control town Sørumsand had a total of 107 individuals: 24 children (14 boys and 10 girls); and 83 adults (28 men and 55 women). Table 1 compares various population characteristics of the inhabitants of the three regions.

2.4 ESTIMATION OF AIR CADMIUM EXPOSURE

It has been conventional until recently to estimate ambient exposure to a pollutant by using one or several air stations placed outdoors. However, more recently, it has become accepted that exposure to air pollution is dependent on those levels individuals are in reality exposed to, that is, in their homes at work, outsides, etc. With the increased research in the domain of indoor air pollution, the importance of the home as a source of air pollution exposure has been documented. To define an individual´s exposure to air pollution, it is now accepted that it is desirable to map out individuals movements through differing microenvironments during the course of a day or days (Ott, 1985).

Table 1: Population characteristics of the three towns where urinary and air cadmium concentrations were measured: Oslo-Nydalen (moderate air cadmium levels originating from industrial sources), Holmestrand and Sørumsand.

	Oslo-Nydalen		Sørumsand		Holmestrand	
Sample size	470		107		149	
Age range	2 - 98 years		3 - 91 years		3 - 92 years	
Numbers of:	male	female	male	female	male	female
Children (0-4 yrs)	10	3	2	1	1	1
Children (5-10)	52	42	8	5	2	3
Children (11-15)	47	32	4	4	7	7
Adults (16-66)	109	136	25	50	34	61
Pensionists (>66)	16	23	3	5	14	19
Socio-economic factors	(Percentage of population)					
Social Class A*	27%		52%		18%	
" " B	29%		17%		29%	
" " C	16%		20%		20%	
" " D	0.05%		4%		8%	
" " E	0%		5%		0%	
those on public assistance F	-		3%		9%	

* Definition of social class divisions is given in Appendix II. Pensionists are excluded since occupation is unknown.

Microenvironments can be defined differently dependent on resources or pollutant of interest. However, commonly used microenvironments include indoors at home, outdoors near home, outdoors in a highly exposed area, indoors at work and so forth. Some studies have even looked at individual rooms inside a house.

Measuring pollutant exposure in populations at the microenvironment level can be done by two methods. The first and decidedly best method is to use portable monitors that individuals carry around with them for a fixed period of time. The three major disadvantages with this technique are: 1) portable equipment is not currently available for very many compounds and due to the bulk of carrying such equipment only one pollutant can be measured at any one time; 2) when such equipment is available it is costly, and requires much technical assistance, so that experimental studies using these instruments are very costly and limited in the number of participants; and 3) the inconvenience of carrying such equipment can lead to study participants altering their lifestyle slightly but significantly, as for example avoiding sports or jogging trips and so forth. The second method is called the diary method. It combines measurements made or estimated in previously defined microenvironments with information provided by the participant himself using a diary, concerning time spent in each of these microenvironments. This method is less accurate, but has the advantage that the number of participants in epidemiological studies can be almost unlimited. The diary method was first described by Moschandreas (1981) and Duan (1982).

The diary method was used in this study to approximate individual air cadmium exposure over the recent past. The estimated exposure estimate also accounted for smoking indoors.

2.4.1 Fixed outdoor stations

Oslo-Nydalen:

A total of four fixed low volume samplers were placed for this study in the Nydalen region, in addition to using two already existing stations in downtown Oslo. Thus, 6 outdoor stations were used for estimating air cadmium exposure during the experimental period, February 1984, in Oslo (Figure 2). Each intake was situated at a height of 2 meters. Twenty-four hour samples were collected for a minimum of thirty days at each site. The four Oslo-Nydalen stations were placed in different directions from both the industrial sources and the highway, yet in areas where people lived: 1) relative to the industrial point sources - to the northeast, east, southeast, southwest and west; 2) relative to the main highway - two to the north and three to the south. The other two sites were in downtown Oslo one with high traffic, and one city background station).

Holmestrand:

Two fixed low volume samplers were placed such that the intake was situated at a height of 2 meters. Twenty-four hour samples were collected for over a 30 day period. The sites in Holmestrand were chosen (Figure 3): 1) to the north of the crosslight because of proximity to an old people´s home where thirty of the participants of the study lived, and 2) to the south of the crosslight near a school that was attended by nearly all the children in the area.

Sørumsand:

Two fixed low volume samplers, of the same type as used in Oslo-Nydalen and Holmestrand, were placed also such that the intake was situated at a height of 2 meters. Twenty-four hour samples were collected for 29 days. In Sørumsand, the sites were placed in areas where most of the volunteers lived (Figure 3).

2.4.2 Indoor air samplers

Portable 8-hour samplers were distributed to shops, schools and private individuals living in the experimental area (Figures 2 and 3). Generally 3 consecutive 8-hour samples were collected at each site (generating a full 24 hour sampling period). Some, such as in shops and schools, were collected for a shorter period.

The values of ambient cadmium measured indoors were difficult to interpret because of a fairly large blank filter value. Therefore, it was decided to use the information collected on the relationship of indoor and outdoor ambient lead as being representative for cadmium and more accurate. Ambient lead concentrations were found to vary by house-type (new apartment, old apartment, house, etc.) and coefficients for indoor air (characterized as ranging from 35% to 60% of outdoor values) were used dependent on characteristics of the volunteers homes. In addition, indoor samplers were used inside cars to estimate the exposure to cadmium during car transit in the city.

2.4.3 Chemical analysis of ambient cadmium

Particulate bound cadmium (<10µm) was collected on Whatman 40 cellulose fiber filters by the low volume samplers for outdoor air and Millipore AAWP 0.8 µm mixed cellulose acetate membrane filters for the indoor air samples.

Ambient cadmium was determined at the Norwegian Institute of Air Research by electrothermal atomic absorption spectroscopy (EAAS) after extraction of the cadmium from the filters with 1:1 nitric acid.

Analyses were made by a Perkin-Elmer 2380 atomic absorption spectrophotometer equipped with a P-E 400 graphite furnace, an AS-1 automatic sampler, a PRS-10 printer, a Model 56 recorder, a deuterium arc background corrector and a cadmium hollow cathode lamp. Ordinary graphite tubes were used throughout this study. A summary of the air method is listed in Table 2. The detection limit of the analysis is 0.05 μgCd/l which corresponds to 0.15ng Cd/m^3 for the outdoor samples (10 ml extract, 3.5 m^3 of air). The precision is about 5% at the 3 ng Cd/m^3 level. The calibration standards used are diluted Titrisol ampoules (Merck) diluted with nitric acid to approximately the same acid concentration as in the samples.

Table 2: Summary of air cadmium method.

Sample preparation

1:1 HNO_3 is added to cut pieces of the filter in polythyhylene centrifuge tubes (2 ml in the case of outdoor sampler, 1 ml for indoor samples). The tubes are left in a water bath at 80^0C for 1 hour. 8 or 4 ml of distilled water is added and the tubes are shaken and centrifuged.

Instrumental parameters

Wavelength	228.8 nm
Spectral band width	0.7 nm
Lamp current	4 mA
Read time	3 sec
Signal mode	Peak height

Furnace/autosampler program

Sample volume 20 μl

	Temp ^0C		Ramp/hold (sec)
Dry	120		2/40
Char	250		5/30
Atomize	2100	Argon flow 20 ml/min	1/3
Clean out	2300		1/1

The two types of filters used in the outdoor and indoor samplers, differ in the range of particle size they trap. In addition to filter type, physical characteristics of the sampler are also an important factor in determining what size particles are trapped. The outdoor low-volume samplers collect inhalable particles whose largest diameter varies from 10-20 µm dependent on wind velocity. However, 10 µm is a more reliable figure based on the construction of the sampler. The filter determines the smallest diameter. The filter used allows ca 80% efficency of recovery for particles 0.10 µm or less. In the indoor, portable sampler, the particles do not travel through tubing but impact the filter directly allowing larger particles (<15 to 20 µm) to be collected, that are not influenced by wind speed. The quality of the filters allow for the portable sampler, a 99.999% efficiency of recovery for particles 0.035 µm in diameter.

2.4.4 Diary information

A series of questions in the self-administered questionnaire, aimed at enabling the estimation of exposure, asked about:

1) Location of home, school or work in the town:

   a) The area surrounding Oslo-Nydalen was divided into 12 sub-regions where air cadmium was either directly measured or estimated. In addition, ambient cadmium was measured at 2 stations in downtown Oslo and estimated using results of modelling of air transport in Oslo (Gronskei et al., 1982)
   b) In Holmestrand, the area was divided into 6 regions, where people either worked or lived. The divisions were made because of the lead study, to take into account regions with differing amounts of traffic. Since traffic pollution is not considered a source of cadmium, this was not a very important division in Holmestrand for the cadmium investigation.
   c) In Sørumsand, four general living areas were isolated. This division appeared less important since air cadmium levels seemed relatively uniform over the entire area.

2) Overviews were acquired of time spent: indoors at home, indoors at work or school, outdoors at home, outdoors at work or school, time spent jogging or in heavy activity and time spent travelling for the 14 days prior to urine sampling.

2.4.5 Individual air cadmium exposure estimate

Cadmium levels in urine reflects the build-up of cadmium in kidneys through a lifetime, and therefore reflect a long accumulation period. Nevertheless, exposure estimates for air cadmium were calculated based on the 14 days prior to each individual urine sampling. These were calculated 1) to assure that urinary concentrations do not reflect recent exposure, since the diary method has not been used before in such studies; and 2) to provide a rough estimate for individuals relative exposure to ambient cadmium by making the assumption that they have lived in their present homes a good portion of their lives. The final air matrix used for estimating air cadmium exposure consisted of daily cadmium measurements for each station over a 30 day period. The air cadmium values used in this study are found in Appendix I.

An overview of the method used in this study to estimate air cadmium exposure is given in Table 3. Essentially the method combines measured values of indoor and outdoor cadmium with 1) factors to account for housetype, activity level etc; 2) factors that estimate ambient cadmium in different microenvironments. Coupled with the diary, the estimates for each microenvironment can then be used to estimate daily and weekly exposure to ambient cadmium.

The individual air cadmium exposure estimate takes into account time spent indoors and travelling. Factors were included to account for different indoor to outdoor ratios caused by varying house type (see paragraph 2.4.2). A fixed factor of 1.5 ng/m^3 was added to the indoor exposure estimate of all those who admitted either to being smokers themselves or to being exposed to passive smoking. This factor was arrived at from indoor measurements in different homes and work places. An extra factor was used if people were actively jogging to account for increased respiratory rate (X 2). Likewise, a factor (1.2) was used to account for higher activity in children when they were outdoors, since they were usually playing. (Factors found both in consultation with lung specialists and Åstrand and Rodahl,1977). Since we believe that these corrective factors give a more accurate estimate of air cadmium exposure, they are incorporated into all further analyses.

Table 3: Overview over calculation method for estimating short term exposure to cadmium

Geographic area	Time - Days Day 1	Day 2	Day 3	..30d.
Area A				
Area B				
Area C				
Area D				
Area E				
Car				
Oslo cen1				
Oslo cen2				
Oslo cen3				

+

INDOORS/OUTDOORS
COEFFICIENT MATRIX

Building Type	Window/Vent open/closed	

+

DIARY

Microenviron	TIME Day 1	Day 2	Day 3	Day 4	...
Home inside					
Home outside					
Work/School					
inside					
outside					
In car					
Downtown					

+

COEFFICIENT MATRIX TO
ACCOUNT FOR LUNG VENTILATION
FROM ACTIVITY LEVEL

Activity Type	Coefficient

The method is of course not the ideal one for cadmium, since cadmium builds up in the body over a lifetime. However, it does give a rough indication of differences in exposure to ambient pollution both through area of residence and lifestyle (time spent outdoors etc.)

2.4.6 Measurements of cadmium in dust, snow and drinking water

In order to assure that urinary cadmium values in the study area did not reflect intake from other possibly important sources such as cadmium in dust, snow in playgrounds, or from drinking water, a few extra measurements of snow and drinking water were made.

Measurements were made of outdoor dustfall in Holmestrand and Sørumsand using a NILU dust collector which is a long funnel shaped container holding a filter and a trap underneath to collect precipitation. It stands at a height of 1.5 m. The sampling period is indicated in Table 10. Cadmium was analyzed both in water soluble and water insoluble dusts in the same laboratory (NILU) using the same methods as for air samples.

Indoor dust samples were also collected in Holmestrand and Sørumsand by washing a square surface (10x10 cm) in the dustiest corner of the house with a distilled water soaked filter. The filters were then stored in sterilized glass bottles. Cadmium was measured in the same laboratory using the same methods as described in 2.4.3. This indoor dust method was first described by Vostal et al., in 1974.

Surface snow samples were gathered in fields where children were most likely to play, at all the schools and kindergartens. In addition, one sample was collected within the industrial zone. Measurements of cadmium in snow reflect deposition of cadmium from the air and thus were also used to estimate air cadmium values of the 12 subdivisions mentioned in 2.4.3.

The samples represent several centimeters depth and were collected on the 29th of February. A small amount of snow fell on the 24th (0.1 mm precipitation) and 22nd (0.3 mm precipitation) that did not considerably increase snow depth. It is necessary to go back to the 16th and 17th (13 days prior to sampling) where 3 centimeters of snow fell to find a more substantial snowfall (Meteorological Institute - personal communication).

A 20 ml sample of drinking water was obtained in acid washed polyethylene bottles from the main faucet in the house or building. Water was allowed to run for a few minutes before sampling.

2.5 URINE MEASUREMENTS

2.5.1 Collection of urine samples

From each individual 5-25 ml urine was collected in NUNC Universal container having a capacity of 25 ml and made of polystyrene/polyethylene (Nunc Intermed, Denmark).

Urine sampling was done in February 1984 in Oslo-Nydalen and May 1984 in Holmestrand and Sørumsand. The urine samplers were provided to each individual in advance, allowing for collection of morning urine.

The urine samples were analyzed for creatinine immediately upon arrival to the laboratory and kept frozen until the cadmium determinations (-20^{0}C).

2.5.2 Determination of creatinine in urine

The determination of creatinine in urine is based on the work described by Jaffe (1886) using a Beckman Creatinine Analyzer. Analyses were done by the Institute of Occupational Health.

2.5.3 Determination of cadmium in urine

Contamination of samples from sample containers is negligible; 2% nitric acid extraction of the containers used for urine collection showed maximum extractable Cd-concentrations of 0.01 µg/l.

Cadmium concentrations in urine were determined at the Institute of Occupational Health by electrothermal atomic absorption spectroscopy (EAAS) using a Perkin-Elmer 5000 atomic absorption spectrophotometer equipped with a P-E 500 graphite furnace, an AS-40 automatic sampler, a PRS-10 printer, a Model 56 recorder, a deuterium arc background corrector and a cadmium electrodeless discharge lamp. A summary of the urine cadmium method is listed in Table 4.

Pyrolytical coated graphite tubes were used throughout this study. The within-run precision of the method was typically 4 - 6% and 1 - 3% at the 0.5 μg Cd/l and the 2.0 μg Cd/l levels respectively.

The day-to-day precision using standard reference urine materials was 3.5%. The detection limit of the method was 0.01 μg Cd/l (2X noise level).

The accuracy of the method was established using human urine standard reference materials (Seronorm urine trace elements batch 108, NycoMed A/S, Oslo). The average Cd concentration over the analytical period was 6.4 μg Cd/l (± 3.5%). The proposed reference value based on results from 34 different laboratories is 6.2 μg Cd/l.

2.6 MEASUREMENT OF HEMATOLOGIC PARAMETERS

Hematologic parameters were measured in conjunction with the primary lead study. After arriving at the Institute of Occupational Health the day after collection, hematocrit (red blood cell volume in per cent of whole blood) was determined in duplicate using microhematocrit centrifuge (LIC HK4) at 9500 g for three minutes.

Hemoglobin was measured by the standard cyanmethemoglobin method using photometer (Linson 3).

Zinc-protoporphyrin was determined in whole blood with a ZnP Model 4000 Hemato fluorometer (Environmental Sciences Associates, Inc., U.S.A.). Since ZPP is concentrated inside the red blood cells, whereas the analysis was done using whole blood samples, the zinc-protoporphyrin values were adjusted to a standard hematocrit of 45%.

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Table 4: Summary of urinary cadmium method

Sample Preparation

Dilute urine 1:0.1 with matrix modifier* into the sampler cup. Use the method of standard addition (internal standard concentration 1 µgCd/l).
* 30% HNO_3

Instrumental Parameters

Wavelength	228.8 nm
Spectral Band Width	0.7 nm
Electrodeless Discharge Lamp	6 W
Background Corrector	On
Read Time	5 sec.
Signal Mode	Peak height
Average	2

Furnace/Autosampler Program

Sample volume 15 µl, pyrolytical graphite tubes.

	Temp. ^{0}C		Ramp/Hold sec.
Dry	120		5/15
Char	400	Baseline 12	10/20
Atomize	950	Max Power	0/5
		Recorder	-5
		Read	-1
		Int argon flow	50 ml/min
Clean out	2700		1/2

2.7 CONTROL FOR ADDITIONAL CONFOUNDING FACTORS

The self-administered questionnaire provided information on smoking habits, exposure to passive smoking, and exposure to cadmium through hobbies and occupation. In addition, such information as sleeping with window open, eating of snow, etc. was revealed.

The smoking information was detailed, and covered number of cigarettes smoked and/or grams of tobacco for pipes and/or cigars. In addition, information was obtained about previous smoking history, time elapsed since quitting and whether or not the individual was still an occasional smoker. Children were asked if they smoked. All children, non-smokers, former smokers and occasional smokers were asked whether or not they were exposed to passive smoking and for how many hours per day. A review of the definitions inherent in each smoking category is given in Table 5.

Table 5: Definition of subgroups used in data analysis.

1) CHILDREN 2 - 15 YRS

   A) NOT EXPOSED TO PASSIVE SMOKING
   B) EXPOSED TO PASSIVE SMOKING

2) WOMEN 16 - 98 YRS

   A) NON-SMOKERS
      - Have never smoked
      - Are not exposed to passive smoking
      - Do not occasionally smoke

   B) FORMER SMOKERS
      - Former smokers who quit 3 months ago or more

   C) SMOKERS
      - Persons who smoke more than 1 cigarette/day
      - Persons who have quit smoking for less than 3 months

3) MEN 16 - 90 YRS

      - Same as for Women

Occupational exposure to cadmium covered both current and previous exposure.

Information provided by children was verified by comparing that given by the parents where possible.

All individuals were classified into social category by occupation; for housewives by occupation of spouse; for children by occupation of male parents followed by female parent. The classification system used (Skrede, 1971) divides occupation into five classes (see Appendix 2).

2.8 DATA ANALYSIS

Creatinine adjusted urinary cadmium and estimated air cadmium exposure (CdA) along with the measured social and biological parameters were analyzed using conventional statistical packages DDPP (Jakobsen, 1982) and SPSS (Nie et al., 1975).

3 RESULTS

3.1 INDIVIDUAL AIR CADMIUM EXPOSURE

3.1.1 Cadmium in outdoor air in Oslo-Nydalen, Holmestrand and Sørumsand.

Cadmium in outdoor and indoor air was measured in Holmestrand and Sørumsand both in the 1983 and 1984 studies, in addition to being measured in Oslo-Nydalen in 1984. Table 6 gives means and standard deviations in addition to minimum and maximum values measured at each of the outdoor stations in 1983 and 1984. During the Oslo-Nydalen investigation that took place in February 1984, measurements were also made in downtown Oslo (St. Olavs gate).

It is evident looking at Table 6, that ambient concentrations of cadmium in the Nydalen area are higher than those measured in Sørumsand or Holmestrand. Maximum ambient values in 1984 are 2.3 and 5.7 ng/m^3 in Sørumsand, 2.3 and 5.6 ng/m^3 in Holmestrand, whereas they are between 6.7 and 29.9 ng/m^3 in Oslo. It should be pointed out that values in Sørumsand and Holmestrand, during both years, were measured in May, whereas those in Oslo-Nydalen were measured in February. Meteorological conditions lead to seasonal variations in ambient concentrations of cadmium. Differences in annual means of the three locations are most likely not as large as these values indicate. The four stations in the Nydalen area are placed to the north, south, east and west of an industrial area that includes one source that releases some cadmium into ambient air. Examination of the values in Table 6, indicates that the stations to the south and west of the complex have the highest values presumably because of a predominance of northeasterly winds in winter. Thus it is possible that the high values measured further south in downtown Oslo (highs of 12.7 ng/m^3) reflect in part, transport from the industrial zone into the center of town.

Holmestrand was originally chosen as an area that in 1983 had high ambient lead levels because of a large amount of through traffic on a major traffic artery that crossed the town, and was stopped by a traffic light. However, a tunnel was opened that diverted the traffic from the town. Therefore in 1984, a year later, the town was relatively free from vehicular traffic. Since cadmium is not released in traffic emissions however, it was not expected that levels of ambient cadmium in Holmestrand would be higher than the control town, Sørumsand. The values in Table 6 confirm these suppositions. Neither Holmestrand nor Sørumsand had industrial sources of cadmium. Table 6 also shows lower values for cadmium in air in 1983 than in 1984 in Holmestrand and Sørumsand.

Table 7 shows selected values measured in February 1971 at sites relatively near the ones used in the study in the Oslo-Nydalen area. These values thus represent concentrations measured before air filtration systems were installed in the factory. The pattern is very similar to the one seen in the 1984 study. The values in Table 7 are only for a few selected dates and therefore do not represent normal values for the month of February. The dates were selected to represent various meteorological conditions in the month of February. They are probably higher than average values. The highest values, 24 and 28 ng/m^3, were measured to the south and to the west of the industrial complex. These values are similar to the maximums measured in this study.

Table 8 attempts to relate the ambient cadmium values measured in this study with those measured elsewhere in Norway and in the European Economic Community. The values measured in Sørumsand and Holmestrand are equivalent or slightly higher than Norwegian background values whereas they are substantially lower than European rural values. The downtown Oslo values are slightly higher than most smaller Norwegian towns. The values measured at Oslo-Nydalen are under those measured at Sulitjelma or Sauda. They are also lower than the European industrial sites, being more comparable to European urban values.

In order to further confirm the supposition that cadmium in air in the Oslo-Nydalen area stems primarily from the two industrial sources, it is possible to look at the ambient cadmium values as a function of wind direction. In Table 9, days were selected for being fairly

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representative for a single wind direction. One can see that on those days that wind was primarily from the north, those stations to the north of the industrial complex had little cadmium in air, whereas, those to the south had more. One must be careful in interpreting wind direction, since these values were measured at a meteorological station slightly west of the Oslo-Nydalen area (Blindern). The Oslo-Nydalen area lies in a valley with a predominant northwest-southeast axis that may result in locally different wind directions than those measured at Blindern.

Table 6: Cadmium (ng/m^3) in air in Oslo, February 1984 and Holmestrand and Sørumsand, May 1983 and 1984.

	Oslo-Nydalen					Sørumsand		Holmestrand	
	W *	S	E	N	Down-town	St. 1	St. 2	St. 1	St. 2
1983									
Mean						0.29	0.30	0.37	0.39
Standard deviation						0.28	0.31	0.24	0.31
No.						36	28	42	34
Min.						0.05	0.06	0.06	0.13
Max.						1.61	1.75	1.24	1.84
1984									
Mean	2.45	6.32	1.37	2.07	2.08	0.84	0.64	0.96	0.68
Standard deviation	4.89	7.71	1.52	2.90	2.45	1.18	0.47	0.92	0.40
No.	42	40	33	39	29	29	22	35	36
Min.	0.07	0.10	0.13	0.22	<0.05	<0.26	<0.26	<0.29	<0.27
Max.	29.9	25.5	6.73	10.87	12.7	5.74	2.26	5.56	2.30

* Directions refer to direction of sites with respect to the industrial sources.

Table 7: Ambient cadmium (ng/m^3) measured in Oslo in February 1971, before bag filters were installed at the factory. Stations were relatively near the ones in this study.

Station Date	Ullevål Hospital	Sagene	Grefsen	St. Olavs plass
Closest study site in this study	W	S	E	Downtown
Dates *1 4-5/2	7	11	7	9
10-11/2	11	8	4	7
11-12/2	7	4	4	1
24-25/2	4	13	3	3
7-8/3	24	28	6	8

*1 Dates were selected to reflect different meteorological conditions.
Source: Joranger et al., 1977.

Table 8: Ambient levels of cadmium (ng/m^3) in Norway and in the European Economic Community.

		NORWAY *1				INTERNATIONAL *2			
Location	Rural	Location	Urban	Location	Industrial	Location	Rural	Urban	Industrial
		THIS STUDY							
		Oslo	2.1	Oslo-Nydalen	1.37-6.32	U.K.	1-2.7	3.6-8.9	200-11000
		Sørumsand	0.3-0.9						16.5-40
		Holmestrand	0.3-1.0						
Birkenes	.11-.34[1]	Halden[3]	1-1.5[3]	Sulitjelma	60-180[2]	Belgium	4-6	8-15	18-54
Vasser	.30-.46[1]	Askim	4[3]	Notodden	5.4[3]				
Svanvik	.49[4]	Moss	1[3]	Sauda	6-15[3]	FRG	2.1	6.1	
Jergul	.13[4]	Sarp./Fred.	0.5-1.0[3]						
		Lillestrøm	1-8[3]			Netherlands	5		
		Hamar	1-3[3]						
		Kongsvinger	0.5[3]			France		20	
		Gjøvik	2.5-6[3]						
		Lillehammer	0.5-2[3]						
		Slemmestad	0.5-1[3]						
		Larvik	0.5[3]						
		Sandefjord	0.5[3]						
		Eydehavn	1.5-2.0[3]						
		Kristiansand	1.0[3]						
		Vennesla	0.5[3]						
		Stavanger	1.5[3]						
		Mongstad	1-4.5[3]						
		Ålvik	0.5-1.0[3]						
		Høyanger	2-4[3]						
		Svelgen	0.5-1.0[3]						
		Årdal	2[3]						
		Trondheim	0.5-1.0[3]						
		Kopperå	1.0-1.5[3]						
		Mosjøen	0.5-2.5[3]						
		Narvik	0.5[3]						
		Mo i Rana	0.5-1.0[3]						
		Finnsnes	0.5-1.0[3]						
		Tromsø	0.5[3]						
		Honningsvåg	0.5[3]						
		Kirkenes	0.5[3]						

*1 Values come from 1) Semb, 1978; 2) Sivertsen and Hanssen, 1983; 3) Hagen, 1977 and 4) Hagen, 1981.

*2 Values are summarized in Hutton, 1982.

*3 Values from Hagen, 1977 are from a few selected samples. These means are probably higher than a monthly mean for each area.

3.1.2 Cadmium in outdoor dust

Cadmium in outdoor dust was measured both in 1983 and 1984 in Holmestrand and Sørumsand. The measuring technique allows measuring both water soluble and insoluble fractions. The results are summarized in Table 10. Values of cadmium in outdoor dust over the two years does not follow the same pattern seen with outdoor air cadmium concentrations (see Table 6). Whereas both towns had increased values of cadmium in outdoor air in 1984 as compared to 1983, both had lower total amounts of cadmium in dust. The water insoluble fraction of dust increased in both towns whereas the water soluble fraction (that carried in rain) decreased. This agrees with decreased amounts of rainfall in 1984 as compared to 1983. In the rest of Norway cadmium concentrations in rain in May 1984 were lower than May 1983 (Hagen, 1984; SFT, 1985).

Table 9: Air cadmium values (ng/m^3) as a function of wind direction and direction from the industrial sources. 0^0 = Northerly winds.

Date	N OT vei	E Grefsen skole	S Nydals-veien	W Bakkehaug-veien	Wind direct
2/12	0.72	0.39	1.54	29.90	60
3/12	0.38	0.50	0.78	9.06	50
24/1	1.05	0.25	11.58	0.48	50
28/1	0.27	0.25	4.36	0.71	40
29/1	0.49	0.74	3.00	0.42	50
3/2	0.38	0.50	0.78	7.21	50
5/2	0.22	0.63	0.10	0.50	210
6/2	0.44	0.13	0.85	0.50	200/140
8/2	0.27	0.31	18.20	0.33	15 (11h) 50 (13h)
9/2	5.51	5.00	17.90	4.67	90 (3h) 230 (14h) 60 (7h)
12/2	1.98	0.49	0.39	0.07	230
14/2	10.87	6.73	9.56	4.22	very unruly
15/2	3.73	2.72	2.58	7.27	90 (6h) 200 (18h)
17/2	0.73	0.74	0.94	0.67	200
18/2	0.64	1.05	0.85	1.13	210
20/2	0.43	0.74	21.60	0.60	70
21/2	0.32	-	12.35	1.25	70
28/2	10.30	2.20	3.40	1.84	260
29/2	10.30	2.64	0.37	0.51	240
2/3	0.30	0.61	25.20	0.40	250 (20h) 50 (4h)

Table 10: Cadmium concentrations (in ng/m^2/day) in outdoor dustfall in Holmestrand and Sørumsand during 1983 and 1984. Total volume of water collected indicated in ml in parenthesis.

Site	Dates Sample Col-lected	1983 H_2O insol	1983 H_2O sol	1983 Total	Dates Sample Col-lected	1984 H_2O insol	1984 H_2O sol	1984 Total
Holmestrand	11/4-24/5	123.7	962.8 (3250 ml)	1086.5	26/4-24/5	222.9	131.9 (1205 ml)	354.7
Sørumsand	14/4-15/5	23.1	404.0 (525 ml)	427.1	30 d dates uncertai	110.4	71.3 (480 ml)	181.7

3.1.3 Cadmium concentrations in indoor air and dust

Tables 11 and 12 give average 24 hour indoor air cadmium concentrations (ng/m^3) of various indoor sites in Holmestrand and Sørumsand (Table 11) and Oslo-Nydalen (Table 12), with the outdoor value of the nearest fixed station indicated (sites of indoor samplers as indicated in Figures 2 and 3).

It is evident by examining the values that indoor sources (probably smoking) seem to be more important than outdoor sources in determining indoor concentrations. However, when outdoor levels were very high, indoor values were also high. It is obviously necessary to detail air cadmium concentrations in the indoor environment and population movements within microenvironments to get a correct impression of actual exposure.

The measurements of indoor dust indicate a wide variation both between sites and between years. This reflects an unsatisfactory methodology. It is difficult to properly measure indoor dust. The method chosen in this study attempted so final the highest possible exposure a child, for example, might encounter in a home (see 2.4.6).

3.1.4 Estimation of recent personal exposure to ambient cadmium

When comparing urinary cadmium concentrations in population subgroups it is necessary to take into account the possibility that differences have in part to do with differences in exposure to ambient cadmium. Even though it is well known that cadmium concentration in the urine reflects long term accumulation, it was felt that an exposure estimate based on life style would better reflect exposure over a fairly long term than simply using values at the nearest fixed site. Based on data from smoking homes a factor of 1.5 ng/m^3 was added to the microenvironment every time an individual indicated that he/she was either a smoker or exposed to passive smoking. Using this method, some account is made of the increased burden of cadmium in air when there is smoking without taking into account the portion of cadmium inhaled by a smoker. The frequency distribution of the estimated individual air cadmium exposures is shown in Figure 4 for the population living in the Oslo-Nydalen area, Holmestrand and Sørumsand.

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Table 11: Average 24 hour indoor air cadmium concentrations (ng/m^3) in Holmestrand and Sørumsand in May 1983 and 1984, with corresponding measured outdoor values (ng/m^3) at the fixed stations for the same measuring period indicated. Indoor dust for the same time periods is also given.

Site	Indoor air*1 (ng/m^3) 1983	1984	Indoor dust (ng/m^2) 1983	1984
HOLMESTRAND				
Commercial estb.				
1	0.66	1.31	1059	2100
2	0.81	1.55	150	-
3	1.28	1.32	800	250
Public Bldg.				
1	0.88	1.20	250	2100
2	0.17	1.25	-	-
3	1.32	1.00	1115	1000
Schools				
1	1.68	0.00	1130	700
2	0.87	1.20	-	-
3	0.12	1.75	-	-
Homes				
1(N.S.)*2	0.35	0.25	479	-
2(S.)	1.28	2.92	423	-
Car	-	0.61	-	-
Outdoor val. for same day as indoor ranged	0.06 to 0.47	0.56 to 0.88		
SØRUMSAND				
Public Bldg.	0.07	1.00	No samples taken	
Homes				
1(N.S.)	0.00	2.75		
2(S.)	0.45	2.10		
3(N.S.)	0.00	0.58		
4(S.)	0.00	0.74		
Outdoor val. for same day as indoor ranged	0.05 to 0.75	0.26 to 0.55		

*1 Indoor values were measured using portable pumps and a slightly different filter system than fixed outdoor samplers. This has led to different blank values for the indoor sampler than the outdoor sampler, and therefore comparisons must be made with caution.

*2 N.S. = Non-smoker, S = Smoker.

Table 12: Average 24 hour indoor air cadmium concentrations (ng/m^3) in Nydalen, Oslo, February 1984, with corresponding measured outdoor value (ng/m^3) at nearest fixed station for the same measuring day.

Northeast of point sources: Indoor	Northeast of point sources: Outdoor
2.57	6.55*
0.00	0.27
2.49	1.44
0.00	0.67
0.77	0.27
0.60	0.27
1.72	0.27
0.50	0.27
6.00	5.51

South of point sources: Indoor	South of point sources: Outdoor
1.10	0.38
5.11	2.94
1.16*	1.67
15.38	0.38
14.04	21.6
0.83*	2.22
6.27	3.40
3.05*	1.67
0.82	0.56
0.22	0.38
3.12	2.94

East of point sources: Indoor	East of point sources: Outdoor
2.95	4.55
0.05	0.31
0.70	0.37

West of point sources: Indoor	West of point sources: Outdoor
4.38	0.87
6.86	0.37
2.88*	0.67
0.00*	0.87
0.00*	0.67
0.54*	7.27
1.45*	0.87
0.84*	0.83

Average of 1 to 2 week city car driving
0.54
0.40

* Measurements represent less than 24 hours, for example in schools. See discussion in footnote to Table 11 for comparison of indoor and outdoor methodology.

Differences in:

1) geographic distribution of air cadmium concentrations,
2) individual behavior patterns (e.g. time spent indoors or outdoors, vacationing outside the area, sleeping with open or closed windows),
3) time spent in active sport (e.g. jogging),
4) smoking or exposure to passive smoking,

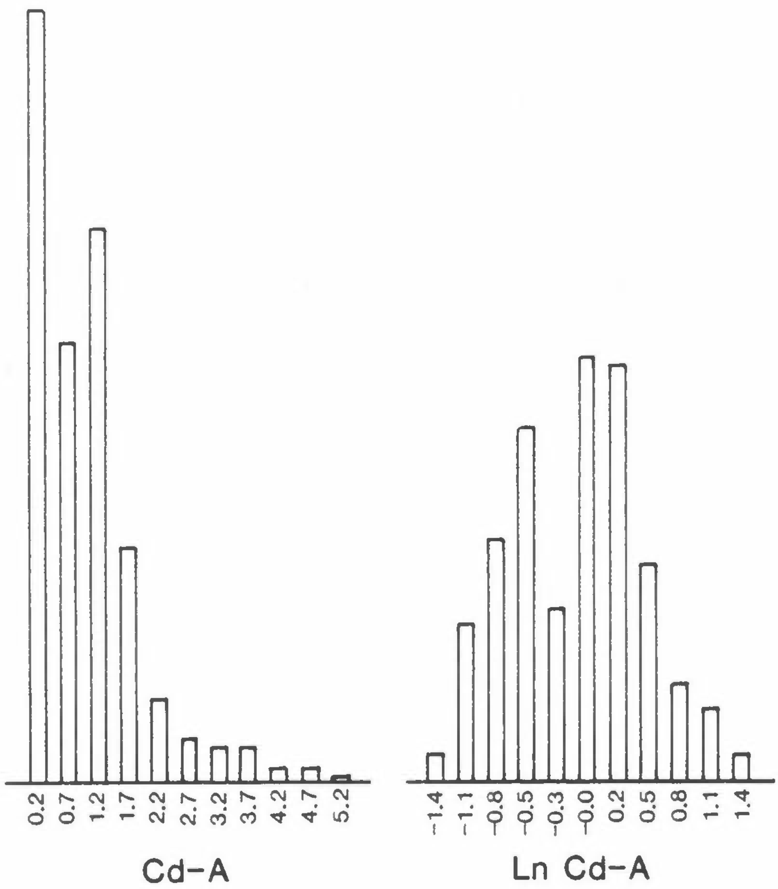


Figure 4: Frequency distributions of exposure estimates to air cadmium (ng/m^3) and their natural logarithms in the population living in the Oslo-Nydalen area, Holmestrand and Sørumsand. See text for description of exposure estimating method.

led to a range in air cadmium exposure from 0.23 to 5.80 or equivalent to a 25 fold range of exposure to air cadmium levels. Differences in individual exposure should be accounted for in evaluating urinary cadmium concentrations.

As can be seen in Figure 4, the distribution of air cadmium exposure estimates is log-normally distributed. Therefore, the natural logarithm of the estimate must be used in statistical analysis.

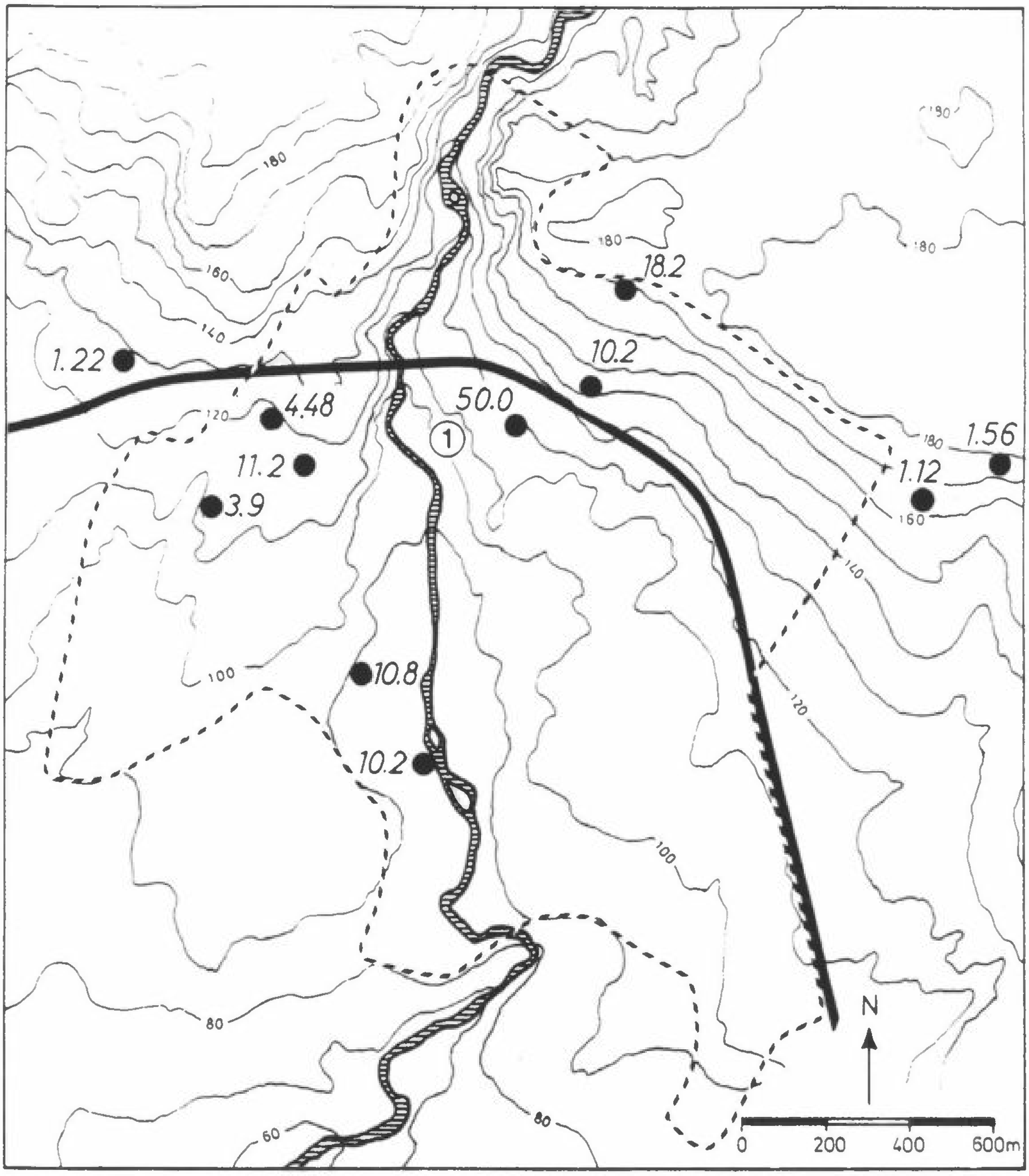


Figure 5: Measured values of cadmium in snow (µg/liter) two weeks after last snowfall. (1) industrial point source;
• snow sample sites;
- Highway 160 with 30 000 vehicles daily.

3.1.5 Cadmium in snow

Only the study in Oslo-Nydalen that was undertaken in the winter allowed measuring cadmium in snow. As shown in Figure 5 cadmium in snow (measured as µg/liter) varied considerably in the geographic area. Snow samples were mostly collected in areas where children were most likely to eat snow; in fields near schools and kindergartens - relatively far from roads.

3.1.6 Cadmium in drinking water

Cadmium was measured in drinking water in all three towns. Out of all the samples taken, only one was over the detection limit (0.05 µg Cd/l) and that had a value of 0.08 µg/l and was in Oslo. Therefore, drinking water cannot be considered a source of cadmium exposure.

3.2 URINARY CADMIUM CONCENTRATIONS

3.2.1 Preliminary data handling

The findings in this report have used the following data correction factors.

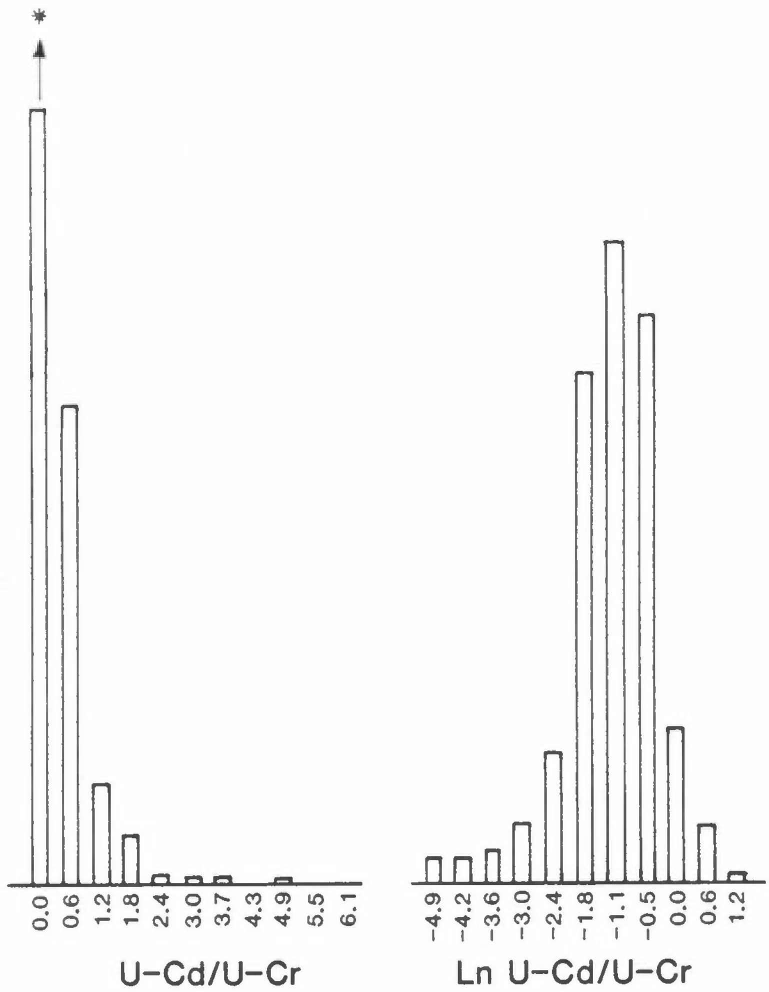
1) Since urine concentration varied between individuals, concentrations of cadmium measured in the urine were adjusted for creatinine. All values where creatinine was measured as under 5 or over 25 mmol/l were considered respectively too dilute or too concentrated, and were therefore removed prior to data analysis.

2) The estimate for individual exposure to air cadmium included a factor to account for increased respiration during high activity (see Clench-Aas et al., 1984).

3) Both air and urinary cadmium concentrations were found to be log normally distributed, and the analyses of statistical significance were run on the natural logarithmic values.

3.2.2 The frequency distribution of standardized urinary cadmium

Figure 6 shows the frequency distribution with accompanying statistics of standardized urinary cadmium concentrations and its natural logarithm. As is evident the distribution is better approximated by a log normal distribution. Therefore the natural logarithms of standardized urinary cadmium were used for all further analysis.



* This column should be twice as high as indicated.

Figure 6: Frequency distributions of concentrations of urinary cadmium divided by urinary creatinine in nmol/l / mmol/l and of the natural logarithm of these values.

The values of urinary cadmium divided by urinary creatinine concentrations ranged from 0.01 nmol/l / mmol/l to 6.79 nmol/l / mmol/l in the Oslo population. In Holmestrand values ranged from 0.07 to 5.05 and in Sørumsand values ranged from 0.10 to 2.28 nmol/l / mmol/l. Occupationally exposed individuals were removed from the data set prior to data analysis.

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3.2.3 Overview over the correlation of urinary cadmium concentrations to air cadmium concentrations and other biological and socio-economic parameters

To assess the statistical significance of the various categorical and continuous variables on urinary cadmium concentrations, an analysis of variance with covariance was performed using SPSS (Nie, et al., 1975). Since questions asked of children were not the same as of adults the data set was divided into two groups, children (15 years or less) and adults (16 years or older). An analysis of variance of this type can be done in two ways. The first is to test the significance of the factors or main effects (categorical data) after having controlled for the covariates (continuous variables). The second method is to control for the factors before controlling for the covariates. Comparing the results from the two methods allows assessing any interaction between covariates and main factors. Significance is defined here as $p \leq 0.05$.

The analysis of variance was run using the following variables. The dependent variable was the natural logarithm of urinary cadmium nmol/l /urinary creatinine mmol/l. The covariates were: age and the natural logarithm of the exposure estimate to ambient cadmium where cadmium in cigarette smoke in the ambient air is accounted for (Log CdA-W).

The categorical parameters or main effects were slightly different for the analyses in children and adults. For children they were: sex, passive smoking, social class, and the town where they live. For adults the main effects were: sex, social class, town where they live, alcohol consumption and current smoking.

In children processing the factors before adjusting for the covariates resulted in no significant results of either main effects, covariates or 2 way interactions using either method of analysis. Reversing the processing order so that the dependent variable is adjusted for the covariates before testing for the main effects resulted however, in the following results: 1) no significant 2-way interactions, 2) significant effect of exposure to cadmium in ambient air, 3) no significant effect of any of the main factors. This indicates that this finding is confounded by an interaction between factors and covariates and thus must be regarded as doubtful. It is considered that processing the factors before the covariates is the most correct form of analysis.

In adults, however, processing the factors before adjusting for the covariates resulted in the following significant results: 1) no significant 2-way interactions between main effects, 2) significant differences for all main effects that is town of inhabitance, sex, smoking, social class and alcohol consumption, 3) no significant effect of recent exposure to air cadmium but significant effect of age. Reversing the processing order so that the dependent variable is adjusted for the covariates before testing for the main effects resulted in the following results: 1) no significant two-way interactions between main effects, 2) significant correlation of both covariates age and exposure to air cadmium, 3) significant effect of all main factors except town of inhabitance. The results where the factors were processed before the covariates are presented in Tables 13 and 14. The results of the analysis where covariates are processed before factors can be found in Appendix 4. These findings seem to indicate that there is some interaction between covariates and main factors, such that caution should used in interpreting the results of the effect of exposure to ambient cadmium and the effect of town of inhabitance. Age is negatively correlated to urinary cadmium when entered before the factors but positive when processed after. It is of course, the latter that is the commonly reported phenomenon and the fact that it is only found after controlling for the factors seems to indicate that for example, that there is a reduced number of smokers among the elderly.

Examination of the multiple classification analysis reveals that: 1) males have lower values of urinary cadmium than females; 2) values of urinary cadmium increase with increased smoking; 3) differences in urinary cadmium resulting from differences in social class that are not reflective of any particular pattern; 4) reduced values of urinary cadmium in those individuals that admit to drinking alcohol at least once a week as opposed to those that claim never to drink or to drink only occasionally. These differences remain after adjusting for covariates and the main factors such as smoking. In both children and adults values for urinary cadmium are significantly higher in Holmestrand than in Oslo-Nydalen or Sørumsand. Passive smoking was not

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found to significantly influence the values of urinary cadmium either in children or in adult non-smokers.

Analysing the data using step-wise multiple regression techniques resulted in somewhat similar findings (Table 15). In children, however, location was significant with those children living in Holmestrand having the highest values. In adults, the same variables of age, sex, smoking and alcohol consumption were significantly correlated with urinary cadmium, confirming the findings described above using analysis of variance. Not unexpectedly, social class was not found significant with multiple regression.

In addition to the analysis of variance, a regular correlation (Phearson´s rho) coefficient matrix was calculated for the data set that is included in Appendix III. Examination of Appendix III reveals most strikingly a greater number of intercorrelations in the adult population than among children.

3.2.4 Detailed examination of the relationship of urinary cadmium with individual explanatory variables

Since age, sex, smoking, and alcohol consumption were significant, the values were tabulated (Tables 16 to 18) for easier comprehension for Oslo-Nydalen, Holmestrand and Sørumsand by 10 year age groups and by smoking and drinking habits in men and women. Extreme caution should be used in examining tabular data in this fashion. Two way data tables such as these cannot take into account the other variables that are also correlated. So for example in values for 10 year age groups, have not been corrected for differences in smoking habits in the different age groups. Therefore the only true test of significance is the analysis of variance with covariance that accounts for all the values simultaneously or stepwise multiple regression. These tables do help to visualize trends however. The results found in the analysis of variance are further suggested in these tables. The data is also visually presented in Figures 7 to 11. UCd/UCr values are not normally distributed, therefore median values are used in the graphs.

Table 13: Results of analysis of variance and of multiple classification analysis of the natural logarithm of urinary cadmium nmol/l / urinary creatinine mmol/l in children.

ANALYSIS OF VARIANCE

CHILDREN 229 CASES PROCESSED; 99 CASES (43.2 %) MISSING

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	9.646	8	1.206	1.045	.407
Location	5.059	2	2.530	2.193	.117
Sex	.104	1	.104	.090	.764
Passive Smoking	.362	1	.362	.314	.576
Social Class	2.611	4	.653	.566	.688
COVARIATES	3.953	2	1.976	1.714	.185
Age	3.941	1	3.941	3.417	.067
Log Ambient Cad	.036	1	.036	.031	.860
2-WAY INTERACTIONS	1.926	12	.160	.139	.999
Loc X Sex	.193	1	.193	.167	.683
Loc X Pas Smok	.010	1	.010	.009	.926
Loc X Soc Cl	.329	3	.110	.095	.963
Sex X Pas Smok	.203	1	.203	.176	.676
Sex X Soc Cl	.597	3	.199	.172	.915
Pas Smok X Soc Cl	.494	3	.165	.143	.934
EXPLAINED	15.525	22	.706	.612	.907
RESIDUAL	123.415	107	1.153		
TOTAL	138.939	129	1.077		

COVARIATE	REGRESSION COEFFICIENT ADJUSTED FOR ALL OTHER COVARIATES
AGE	-.058
LN OF AMBIENT CD EXP	-.061

MULTIPLE CLASSIFICATION ANALYSIS

GRAND MEAN = -1.61

VARIABLE + CATEGORY	N	UNADJUSTED DEV'N	UNADJUSTED ETA	ADJUSTED FOR INDEPENDENTS DEV'N	ADJUSTED FOR INDEPENDENTS BETA	ADJUSTED FOR INDEPENDENTS + COVARIATES DEV'N	ADJUSTED FOR INDEPENDENTS + COVARIATES BETA
LOCATION							
NYDALEN	113	-.08		-.08		-.10	
HOLMESTRAND	16	.59		.57		.64	
SØRUMSAND	1	.14		.38		.62	
			.21		21		.24
SEX							
MALE	70	-.05		-.03		-.02	
FEMALE	60	.06		.03		.02	
			.06		.03		.02
EXP PASS SMOK							
NO	75	.05		.05		.06	
YES	55	-.07		-.06		-.08	
			.05		.05		.07
SOCIAL CLASS							
A	46	-.08		-.07		-.10	
B	46	.05		.13		.18	
C	25	-.17		-.21		-.21	
D	12	.41		.21		.14	
F	1	.91		.32		.33	
			.17		.14		.16
MULTIPLE R SQUARED							.098
MULTIPLE R							.313

Values are adjusted for all factors prior to assessing significance of covariates. Each covariate is adjusted for all other covariates before assessing significance.

Table 14: Results of analysis of variance and of multiple classification analysis of the natural logarithm of urinary cadmium nmol/l / urinary creatinine mmol/l in adult men and women.

ANALYSIS OF VARIANCE

ADULT 477 CASES PROCESSED; 97 CASES (20.3 %) MISSING

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	62.319	17	3.666	6.164	.001
Location	6.374	2	3.187	5.359	.005
Sex	3.260	1	3.260	5.481	.020
Current smoking	17.711	5	3.542	5.956	.001
Social Class	15.397	5	3.079	5.178	.001
Alcohol consumption	7.457	4	1.864	3.135	.015
COVARIATES	20.345	2	10.173	17.104	.001
Age	19.065	1	19.065	32.055	.001
Log Ambient Cad	.522	1	.522	.877	.350
2-WAY INTERACTIONS	38.184	84	.455	.764	.927
Loc X Sex	1.660	2	.830	1.396	.249
Loc X Cur Smok	5.974	10	.597	1.005	.440
Loc X Soc Cl	7.625	10	.762	1.282	.240
Loc X Alc Cons	1.401	6	.234	.393	.883
Sex X Cur Smok	4.954	5	.991	1.666	.143
Sex X Soc Cl	2.078	5	.416	.699	.625
Sex X Alc Cons	1.010	3	.337	.566	.638
Cur Smok X Soc Cl	10.905	17	.641	1.079	.375
Cur Smok X Alc Cons	2.625	13	.202	.339	.985
Soc Cl X Alc Cons	5.869	13	.451	.759	.703
EXPLAINED	120.849	103	1.173	1.973	.001
RESIDUAL	164.151	276	.595		
TOTAL	285.001	379	.752		

COVARIATE	REGRESSION COEFFICIENT ADJUSTED FOR ALL OTHER COVARIATES
AGE	.021.
LN OF AMBIENT CD EXP	-.124

MULTIPLE CLASSIFICATION ANALYSIS

GRAND MEAN = -1.61

VARIABLE + CATEGORY	N	UNADJUSTED DEV'N	ETA	ADJUSTED FOR INDEPENDENTS DEV'N	BETA	ADJUSTED FOR INDEPENDENTS + COVARIATES DEV'N	BETA
LOCATION							
NYDALEN	217	-.16		-.10		-.00	
HOLMESTRAND	99	.36		.24		.09	
SØRUMSAND	64	.00		-.03		-.14	
			.25		.16		.09
SEX							
MALE	156	-.12		-.12		-.15	
FEMALE	224	.09		.08		.10	
			.12		.11		.14
CUR SMOK							
NEVER	159	-.18		-.26		-.28	
PREV	68	.09		.14		.08	
OCCAS	38	-.07		.07		.13	
1 - 9	34	.13		.23		.19	
10 - 29	76	.24		.25		.33	
30+	5	.46		.47		.64	
			.20		.26		.30
SOCIAL CLASS							
A	119	-.15		-.04		.11	
B	122	-.16		-.18		-.07	
C	67	.06		.05		.16	
D	15	.41		.26		.31	
F	14	.13		-.18		-.50	
G	43	.58		.52		-.30	
			.28		.25		.21
ALCOHOL CONSUMPTION							
NEVER	74	.17		.12		.16	
OCCAS	132	.21		.15		.11	
LITTLE	139	-.27		-.20		-.18	
MODERATE	34	-.05		-.02		-.05	
DAILY	1	-.69		-.65		-.16	
			.26		.18		.17
MULTIPLE R SQUARED					.219		.290
MULTIPLE R					.468		.539

Values are adjusted for all factors prior to assessing significance of covariates. Each covariate is adjusted for all other covariates before assessing significance.

Table 15: Result of multiple step-wise regression analysis of the natural logarithm of urinary cadmium nmol/l/urinary creatinine mmol/l.

CHILDREN

THE STEPWISE REGRESSION

NUMBER OF SUBJECTS INCLUDED IN THE ANALYSIS 130

LAST STEP - COEFFICIENT TABLE

VARIABLES IN EQUATION : (CONSTANT= -1.6199) VARIABLES NOT IN EQUATION :

ID	B - COEFFICIENT	STD.ERROR	F TO REMOVE	P-VALUES FOR B	STANDARDIZED B (R.PART)	BETA 95% CONF.INT. UPPER	LOWER	ID	PARTIAL CORR.	TOLERANCE	F TO ENTER
LOC DUM	0.606	0.259	5.455	0.021	0.2022	1.1190	0.0926	AGE	-0.1385	0.9804	2.483
								SEX	0.0422	0.9976	0.2266
								LOC DU	-0.0755	0.4682	0.7271
								LOG CDA	-0.0617	0.5762	0.4858
								PAS SMO	-0.0564	0.9998	0.4048
								SOC CL	0.0437	0.9153	0.2426

SUMMARY TABLE :

STEP NR.	MULT.R	MULT.RSQ	INCREASE IN RSQ	RESIDUAL EFFECT	F-VALUE FOR E/I	VAR. NR ENTER REMOVED	VAR. NAME
1	0.2022	0.0409	0.0409	0.9793	5.455	7	LOCATION-DUM

ADULTS

NUMBER OF SUBJECTS INCLUDED IN THE ANALYSIS 380
THE STEPWISE REGRESSION

VARIABLES IN EQUATION : (CONSTANT= -2.0110) VARIABLES NOT IN EQUATION :

D	B - COEFFICIENT	STD.ERROR	F TO REMOVE	P-VALUES FOR B	STANDARDIZED B (R.PART)	BETA 95% CONF.INT. UPPER	LOWER	ID	PARTIAL CORR.	TOLERANCE	F TO ENTER
AGE	0.018	0.002	67.558	0.000	0.3861	0.0226	0.0139	LOG CDA	-0.0871	0.8010	2.8593
SEX	0.231	0.079	8.509	0.004	0.1348	0.3870	0.0754	LOC DU	0.0514	0.9249	0.9912
SMOK	0.193	0.031	39.345	0.000	0.2941	0.2540	0.1327	LOC DU	-0.0808	0.9387	2.4577
ALC	-0.124	0.045	7.605	0.006	-0.1329	-0.0357	-0.2128	SOC CL	-0.0660	0.4542	1.6366

SUMMARY TABLE :

STEP NR.	MULT.R	MULT.RSQ	INCREASE IN RSQ	RESIDUAL EFFECT	F-VALUE FOR E/I	VAR. NR ENTER REMOVED	VAR. NAME
1	0.3698	0.1368	0.1368	0.9291	59.882	15	AGE
2	0.4444	0.1975	0.0608	0.8958	28.540	28	CURRENT SMOKING
3	0.4707	0.2215	0.0240	0.8823	11.600	12	SEX
4	0.4868	0.2370	0.0155	0.8735	7.605	57	ALCOHOL CONS

It is thus evident that despite higher ambient cadmium in Oslo-Nydalen, than in Sørumsand, urinary cadmium concentrations in the population are not higher in Oslo-Nydalen. The significant correlations of smoking and age in these populations are well-known findings. The significant differences between the sexes is interesting and little discussed in the literature. However, when the analyses were redone with urinary cadmium alone (not standardized for urinary creatinine) then the difference disappeared, indicating that a possible explanation for this finding is that we are measuring sexual differences in creatinine excretion not urinary cadmium. This was further confirmed by similar statistical analysis of creatinine excretion that found a highly significant sexual difference in creatinine excretion (see Appendix IV).

The significant finding of an effect of alcohol consumption on urinary cadmium has not previously been reported. The relationship indicates reduced urinary cadmium concentrations with increased alcohol consumption, a finding that should be further pursued. Repeating the analysis using urinary cadmium that was not standardized for urinary creatinine did not change these findings, indicating an effect on urinary cadmium not creatinine.

Table 16: Cadmium concentrations in urine by 10 year age groups. Values represent U-Cd (nmol/l)/U-Creatinine (mmol/l)

City	Age group		0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-
OSLO	Males	Mean	0.34	0.24	0.50	0.41	0.43	0.72	1.05	1.84	0.85	0.84
		St. Dev.	0.21	0.19	-	0.31	0.27	0.12	0.38	1.40	0.34	-
		N	35	52	1	41	36	4	2	6	5	1
		Median	0.31	0.20	-	0.29	0.38	0.71	0.78	2.15	0.94	-
	Females	Mean	0.30	0.45	0.33	0.58	0.67	1.20	1.50	0.77	0.65	0.67
		St. Dev.	0.23	1.09	0.05	0.56	0.39	0.97	0.81	-	0.29	0.26
		N	33	37	2	66	28	3	3	1	11	4
		Median	0.29	0.22	0.30	0.45	0.61	1.11	1.54	-	0.57	0.55
HOLMESTRAND	Males	Mean	0.39	0.35	0.44	0.62	0.67	0.92	0.70	0.96	1.07	-
		St. Dev.	0.29	0.12	0.11	0.36	0.48	0.30	0.30	0.80	0.23	-
		N	3	7	2	6	6	4	9	5	3	-
		Median	0.28	0.30	0.37	0.68	0.55	0.82	0.72	0.90	1.15	-
	Females	Mean	0.97	0.35	0.75	0.71	0.86	0.91	1.18	0.90	0.58	0.66
		St. Dev.	0.05	0.17	0.39	0.44	0.61	0.78	1.49	0.16	0.65	0.23
		N	2	10	8	10	12	8	12	2	10	3
		Median	0.93	0.26	0.68	0.62	0.59	0.49	0.78	0.79	0.86	0.76
SØRUMSAND	Males	Mean	0.26	0.20	0.22	0.43	0.60	0.57	0.86	-	1.59	-
		St. Dev.	0.10	0.08	-	0.24	0.43	0.24	0.44	-	-	-
		N	4	8	1	8	5	4	2	-	1	-
		Median	0.20	0.19	-	0.34	0.53	0.55	0.55	-	-	-
	Females	Mean	0.39	0.26	0.32	0.48	0.59	0.70	0.32	-	-	2.28
		St. Dev.	0.23	0.06	-	0.19	0.36	0.23	-	-	-	-
		N	6	6	1	14	16	6	1	-	-	1
		Median	0.39	0.25	-	0.41	0.44	0.82	-	-	-	-

* Individuals with a creatinine value under 5 or over 25 mmol/l were considered to have urine that was either too dilute or too concentrated.Occupationally exposed individuals not included for analysis.

Table 17: Urinary cadmium values as a function of smoking. values represent U-Cd (nmol/l)/ U-Creatinine (mmol/l)

	CHILDREN		WOMEN				MEN			
	Not exp. pas.smok.	Expos. pas.smok.	Never smoked	Prev.	Occas.	Smoker	Never smoked	Prev.	Occas.	Smoker
Oslo:										
Mean	0.30	0.27	0.49	0.83	1.02	0.76	0.42	0.44	0.38	0.81
St. Dev.	0.21	0.22	0.35	0.52	1.73	0.64	0.30	0.30	0.28	0.81
N	78	61	63	17	15	33	37	23	10	32
Median	0.30	0.24	0.44	0.77	0.40	0.55	0.42	0.33	0.29	0.55
Holmestrand										
Mean	0.49	0.34	0.84	0.71	1.14	1.05	0.47	0.96	1.15	0.74
St. Dev.	0.30	0.17	0.89	0.65	0.33	0.77	0.27	0.63	-	0.35
N	10	8	33	7	3	24	8	8	1	20
Median	0.35	0.28	0.70	0.50	1.22	0.82	0.35	0.72	-	0.68
Sørumsand:										
Mean	0.27	0.50	0.55	0.60	0.59	0.61	0.35	0.92	0.44	0.63
St. Dev.	0.12	0.38	0.47	0.43	0.28	0.22	0.19	0.46	0.39	0.36
N	17	2	19	10	5	7	6	4	7	6
Median	0.23	0.42	0.42	0.41	0.61	0.61	0.33	0.77	0.26	0.74

*Individuals with a creatinine value under 5 or over 25 mmol/l were considered to have urine that was either too dilute or too concentrated. Occupationally exposed individuals not included for analysis. Children who admitted to smoking were excluded prior to data analysis.

Table 18: Urinary cadmium nmol/l / Urinary creatinine mmol/l in adult men and women by alcohol consumption.

		WOMEN					MEN				
		Never drink	Drink less than 1 per week	Drink at least once a week			Never drink	Drink less than 1 per week	Drink at least once a week		
				Seldom	Often	Daily			Seldom	Often	Daily
Oslo-Nydalen	Mean	0.37	0.83	0.61	0.74	-	0.33	0.72	0.46	0.34	0.24
	St.dev.	0.33	0.58	0.91	0.78	-	0.24	0.49	0.40	0.23	-
	(N)	(87)	(30)	(58)	(10)	-	(96)	(18)	(52)	(14)	(1)
	Median	0.31	0.71	0.45	0.44	-	0.30	0.76	0.33	0.31	0.24
Holme-strand	Mean	0.91	0.95	0.60	0.98	-	0.48	0.79	0.47	0.90	-
	St.dev.	0.76	0.97	0.36	0.50	-	0.28	0.48	0.22	0.46	-
	(N)	(28)	(28)	(15)	(4)	-	(13)	(21)	(6)	(4)	-
	Median	0.76	0.70	0.56	0.78	-	0.35	0.79	0.46	0.64	-
Sørum-sand	Mean	0.74	0.49	0.35	0.76	-	0.46	0.48	0.65	0.38	-
	St.dev.	0.59	0.24	0.08	-	-	0.47	0.24	0.42	0.23	-
	(N)	(13)	(29)	(3)	(1)	-	(8)	(8)	(8)	(2)	-
	Median	0.57	0.44	0.38	0.76	-	0.24	0.37	0.38	0.21	-

*Individuals with a creatinine value under 5 or over 25 mmol/l were considered to have urine that was either too dilute or too concentrated. Occupationally exposed individuals not included for analysis.

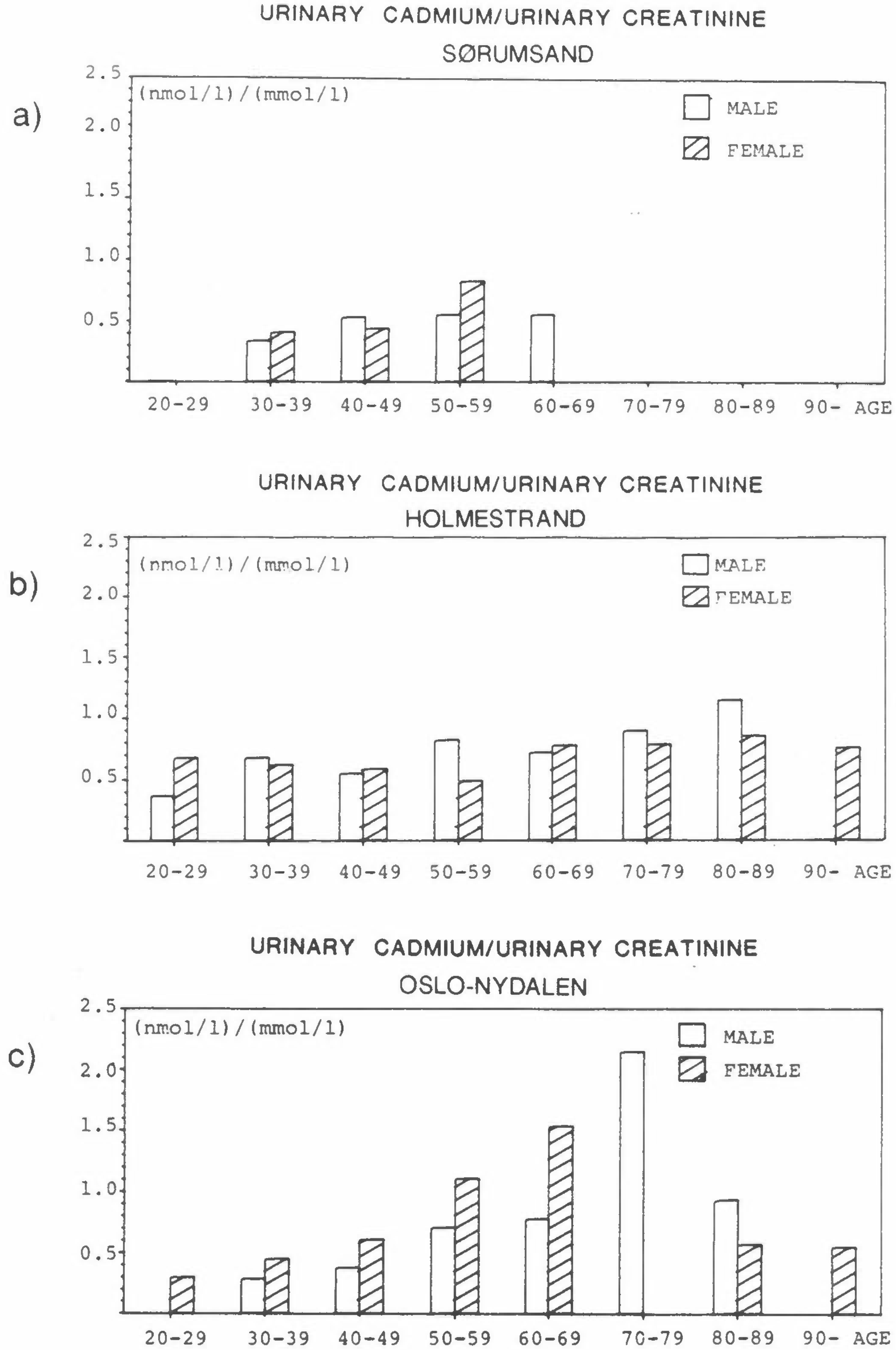


Figure 7: Median values of urinary cadmium (nmol/l)/ urinary creatinine (mmol/l) in adult men and women living in Oslo-Nydalen, Holmestrand and Sørumsand as a function of age group.
a) Sørumsand b) Holmestrand c) Oslo-Nydalen
Occupationally exposed individuals excluded for analysis.

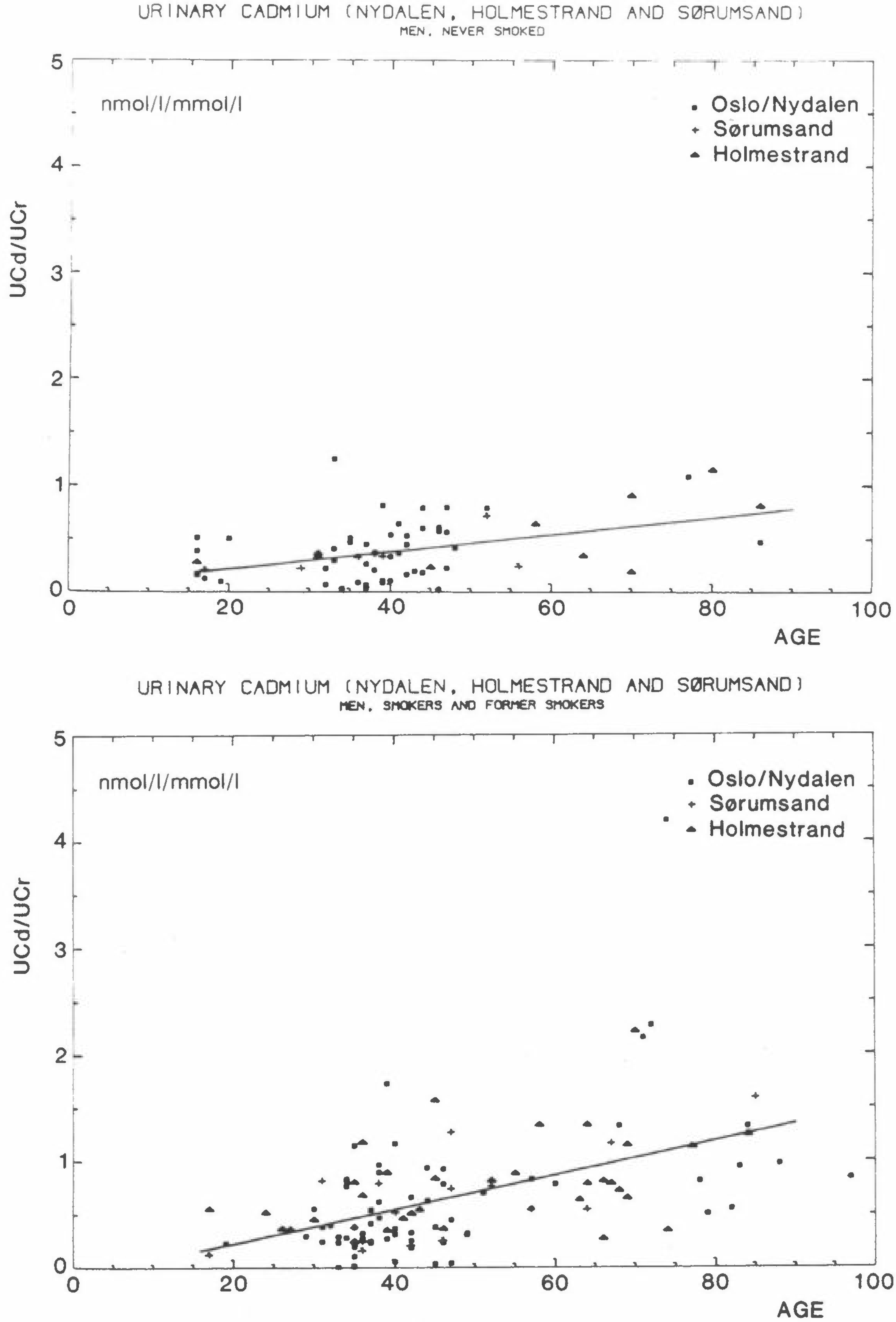
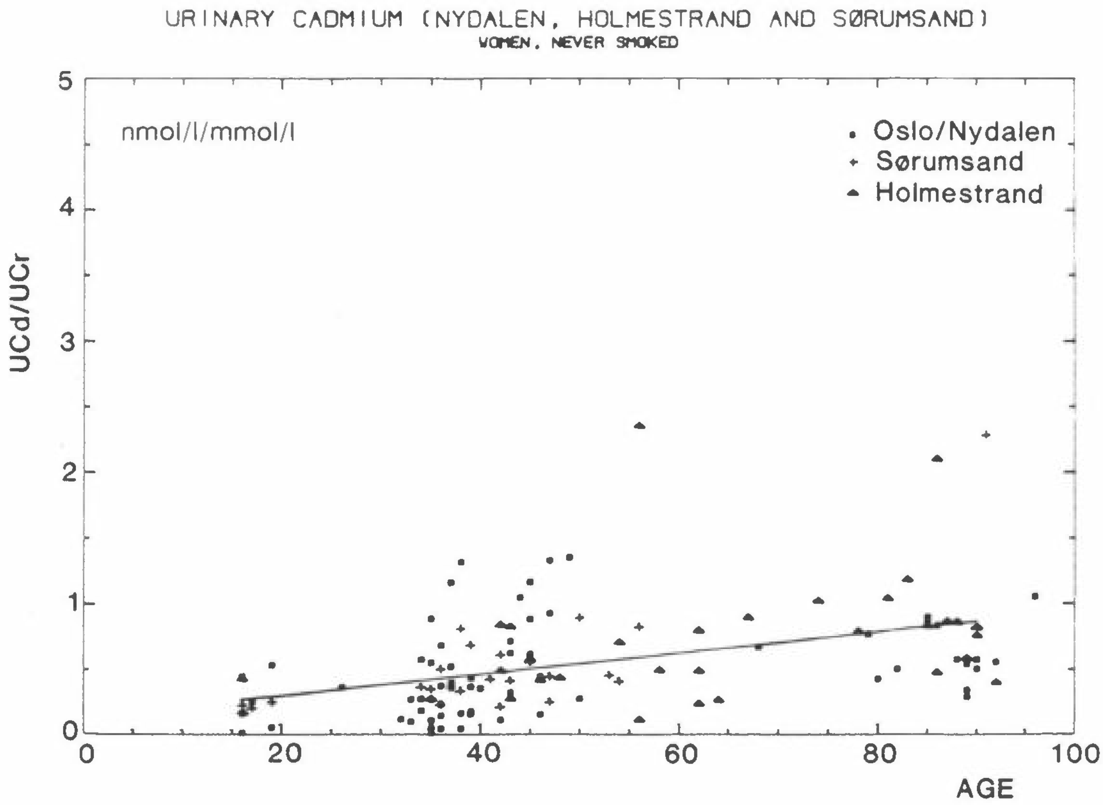


Figure 8: Scatter plot of urinary cadmium (nmol/l)/ urinary creatinine (mmol/l) as a function of age in Oslo-Nydalen, Holmestrand and Sørumsand in non-smoking and smoking men. Occupationally exposed individuals excluded for analysis. The indicated slope reflects the significant regression coefficient of age and U-Cd in each group.



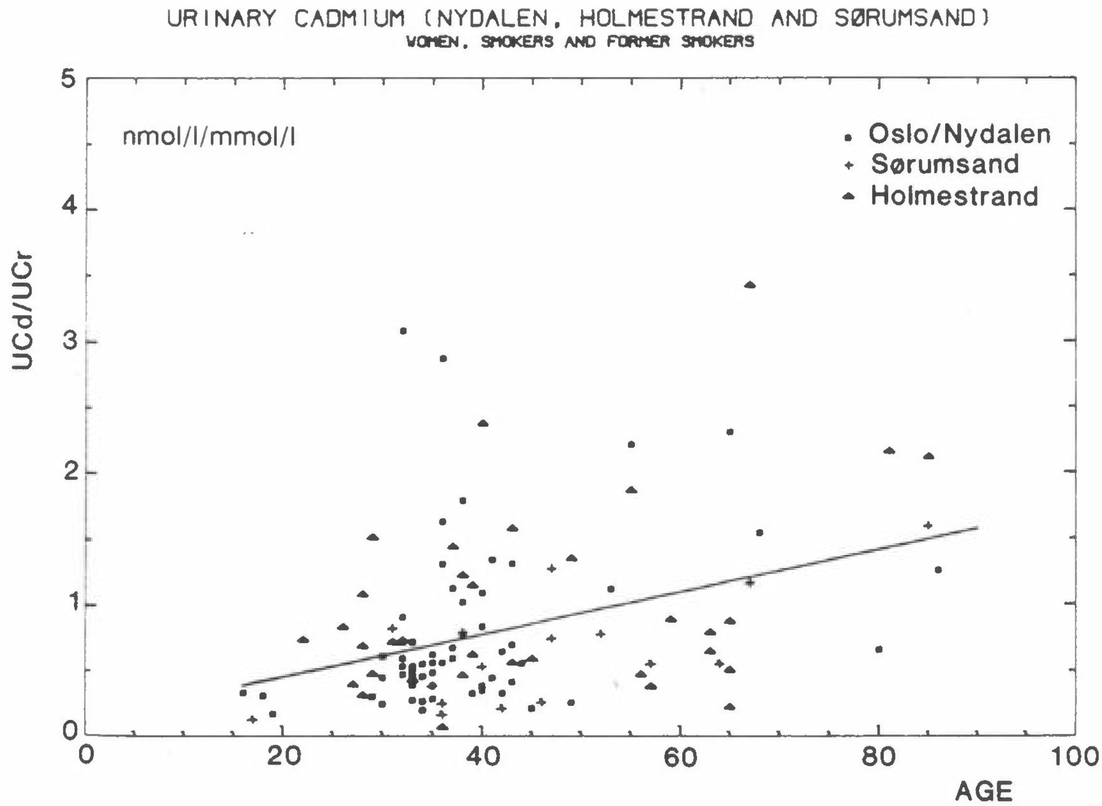


Figure 9: Scatter plot of urinary cadmium (nmol/l)/ urinary creatinine (mmol/l) as a function of age in Oslo-Nydalen, Holmestrand and Sørumsand in non-smoking and smoking women. Occupationally exposed individuals excluded for analysis. The indicated slope reflects the significant regression coefficient of age and U-Cd in each group.

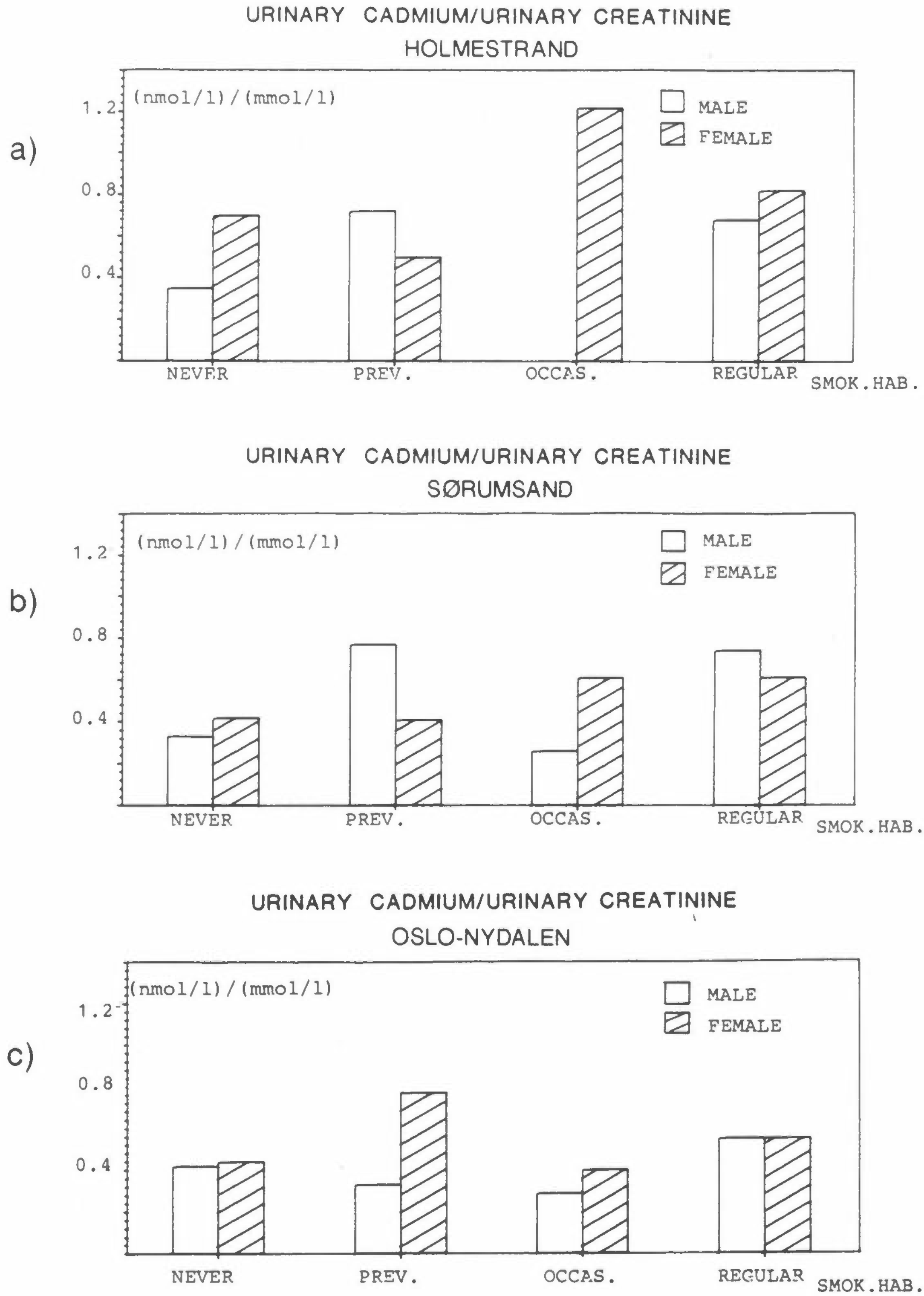


Figure 10: Comparison of median values of urinary cadmium (nmol/l)/ urinary creatinine (mmol/l) in different smoking categories of adult men and women living in
a) Holmestrand b) Sørumsand c) Oslo-Nydalen.
Occupationally exposed individuals excluded for analysis.

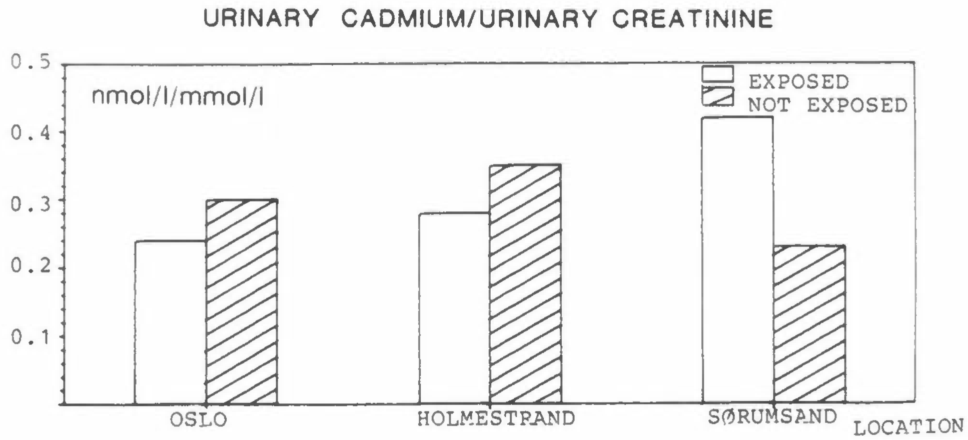


Figure 11: Comparison of median values of urinary cadmium (nmol/l)/ urinary creatinine (mmol/l) in children, exposed or not exposed to passive smoking in Holmestrand, Sørumsand and Oslo-Nydalen. Children who admitted to smoking were excluded prior to data analysis.

3.3 THE EFFECT OF URINARY CADMIUM ON THE HEMATOPOIETIC SYSTEM

Cadmium has been shown to have both acute and chronic effects on the hematopoietic system in man and animal (Elinder, 1986). There have been reported lowered hemoglobin values and decreased PCV. Lead has also been reported to have an adverse effect on the hematopoietic system, although the mechanisms of action of the two metals is probably not the same. The variables in the hematopoietic system measured in this study were: hemoglobin, hematocrit, mean cell hemoglobin concentration and zinc protoporphyrin. The data was analyzed using analysis of variance with covariance (SPSS - Nie et al., 1977). The results are summarized in Table 19.

The results presented in Table 19 test for the effects of the covariants, which in this case are the natural logarithm of U-Cd/ U-Cr and age, before testing for those of the known main effects. MCHC (mean cell hemoglobin concentration), hemoglobin and the natural logarithm of ZPP corrected for hematocrit were significantly correlated with the natural logarithm of U-Cd/ U-Cr in children, whereas hematocrit was not. In adults MCHC and hemoglobin were significantly correlated with the natural logarithm of U-Cd/ U-Cr whereas hematocrit and the natural logarithm of ZPP corrected for hematocrit were not. All these correlations were negative, that is, the higher the ln U-Cd/U-Cr, the lower the MCHC and Hb.

The significant correlations in children between log ZPP and geographic location (values in Oslo-Nydalen significantly higher than those in either Holmestrand or SØrumsand); sex (females higher than males); social class (no specific trend); and passive smoking (those exposed higher than those not exposed), and between MCHC and passive smoking (those exposed higher than those not exposed) are interesting although outside the scope of this report. It is important to note however, that these parameters are complex and caution should be used in drawing conclusions.

Table 19: Significance levels of a set of independent variables on four parameters of the hematopoietic system, hemoglobin (Hb), hematocrit (Ht), mean cell hemoglobin concentration (MCHC) and the natural logarithm of zinc protoporphyrin corrected for hematocrit (log ZPP). Regression coefficients are indicated in parenthesis. a) in children b) in adults

A) CHILDREN	HB	HT	MCHC	Log ZPP
COVARIATES				
Age	.001 (.106)	.001 (.409)	.053 (-.073)	.001 (-.050)
Log U-Cd/U-Cr	.038 (-.147)	.678	.005 (-.296)	.001 (-.127)
MAIN EFFECTS				
Location	.461	.796	.537	.001
Sex	.287	.740	.202	.029
Social Class	.506	.086	.169	.001
Passive Smoking	.358	.583	.012	.051
Iron Consumption	.625	.868	.576	.999

B) ADULTS	HB	HT	MCHC	Log ZPP
COVARIATES				
Age	.077	.677	.009 (-.011)	.324
Log U-Cd/U-Cr	.006 (-.193)	.073	.049 (-.173)	.291
MAIN EFFECTS				
Sex	.001	.001	.001	.001
Social Class	.004	.003	.124	.001
Smoking Habits	.469	.673	.530	.350
Alcohol Consumption	.324	.777	.081	.001
Iron Consumption	.015	.017	.913	.091

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In adults, sex is significantly correlated to all the parameters (males have higher values for Hb, Ht and MCHC, while they have lower values of log ZPP), while social class is correlated to all except MCHC (however no specific patterns). Other interesting correlations to note are alcohol consumption with log ZPP (increased levels with increased alcohol consumption) and iron consumption with hemoglobin and hematocrit. However, the correlation with iron consumption was the reverse of expected, that is lower Hb and Ht with increased iron consumption indicating that iron is consumed mainly when these two variables are low.

The values being correlated are urinary cadmium concentration in a single morning sample and not blood concentrations of cadmium. A measurable effect of cadmium on the hematopoietic system may be considered to be primarily influenced by blood concentrations but also may reflect bone reserves of cadmium. Although the blood concentrations can be expected to be somewhat correlated to urinary levels they will not be fully correlated since urinary levels reflect long term accumulation in the kidneys and blood levels reflect the recent past. However, urinary cadmium concentrations may reflect a closer approximation to bone levels of cadmium. The higher degree of correlations observed in children may in reality reflect that urinary levels of cadmium in children are more closely correlated with blood concentrations than they are in adults.

4 DISCUSSION

Concentrations of cadmium in air in Oslo-Nydalen were substantially higher than those measured in either Holmestrand or Sørumsand. The cadmium was of industrial origin. The other two towns, Holmestrand and Sørumsand, have no local sources of cadmium, and yet showed substantial differences in the amount of cadmium in sedimental dust, especially the water soluble fraction, with Holmestrand having higher concentrations.

It is clear when comparing concentrations of urinary cadmium from the inhabitants of Holmestrand, Sørumsand and Oslo-Nydalen that no greater long-term accumulation of cadmium in the kidney occurred in the Oslo area despite higher ambient values of cadmium in the Oslo-Nydalen area. However, the values of ambient cadmium measured in these three studies do not represent heavily polluted areas. The higher urinary cadmium levels in Holmestrand therefore most likely result from other sources than ambient cadmium. The most likely explanation is local differences in nutritional sources. It is interesting to note that the highest known concentrations of cadmium in moss in Norway were measured in Drammen ca 40 km away (Ruhling et al., 1987). These originated from an old mine. A river going through this mine empties into the same bay where Holmestrand lies. It is not unfeasible that fish caught locally near Holmestrand are contaminated from this source. However, it has been suggested (M. Hutton, personal communication), that cadmium in diesel fuel contributes to higher concentrations of cadmium in the larger particles of dust. It has also been suggested (Harrison, 1979) that higher amounts of Cd measured in dust from carparks and urban streets stemmed from Cd used in tires. Should either of these explanations be the case the higher concentrations of urinary cadmium in children living in Holmestrand may reflect traffic density in the town. Differences in cadmium content of drinking water can, however, be eliminated.

The increased values measured with increased age and smoking are simply confirming well known findings and therefore need no comment.

The measured sexual differences in cadmium excretion when using U-ld/U-Cr are most likely explained by sexual differences in creatinine excretion, since repeating statistical analyses for U-Cd alone removed this association. U-creatine is dependent on muscular mass and therefore, lower in women and children than in men.

It was an interesting finding that passive smoking had no measurable effects on the concentration of cadmium in the urines of either children or adults.

The decrease in urinary cadmium concentrations with increased alcohol consumption which has not been previously reported, is of interest and should be further explored. The possibility exists that alcohol consumption alters metabolism such that cadmium is either excreted or deposited differently. However, one cannot rule out that alcohol

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consumption is a surrogate for other closely correlated socio-economic variables that were not measured.

In order to discuss the comparability of Norwegian values to those reported internationally, urinary cadmium uncorrected for creatinine were compared to values in three papers (Elinder, et al., 1983; Kjellstrøm, 1979; and Kowal et al., 1979) from Sweden, Japan and the United States. The values are summarized in Tables 20 and 21. It is very difficult to compare values in a univariate table when two variables, both smoking and age, have strong impact on urinary cadmium. In Table 20, values were divided by age group but Swedish values only included nonsmokers, Japanese values both smokers and non-smokers, and the United States values both males and females and both smokers and nonsmokers. The Norwegian data includes both smokers and non-smokers, but separates males and females. Norwegian values lie clearly above those from Sweden, but this may purely reflect the effect of smoking. The Norwegian values lie under those of Japan, but seem similar to the values measured in Dallas, yet lower than those measured in Chicago. The higher values measured in women in this study are also seen in the values reported from Japan and Sweden. The differences seem to reflect in part, differences in creatinine excretion between the two sexes.

In order to compare the Norwegian and the Swedish values with each other, we retabulated data from Oslo-Nydalen using male non-smokers only. Because of the sharp reduction in sample size, only values for age groups 10-19 (.191 µg/l), 30-39 (.191), and 40-49 (.472) are relevant. These values indicate that the Norwegian levels of cadmium in urine are comparable to the Swedish values.

Table 21 compares urinary cadmium in smokers and non-smokers and indicates that Norwegian values closely resemble those measured in Dallas and lower than those measured in Chicago. Former smokers is a poorly defined category that is strongly influenced by how long the smokers had been smoking before they quit and how much time has elapsed since they quit.

The possibility that cadmium can influence the hematopoietic system even at these low levels is perturbing. The evidence presented in this report suggests that further research on this subject is warranted.

The significant values found in children give further indication that research is necessary in children. Research is done primarily on adults, whereas children react differently and can even react more strongly than adults or begin reacting at lower concentrations than adults.

An epidemiological study of this type can not be considered to provide definitive answers, but only indications of possible correlation. Findings described as significant in this study should therefore be considered as basis for further detailed study rather than a conclusive result.

Table 20: Comparison of the medians of urinary cadmium values measured as µg/l *1 in the inhabitants of Oslo-Nydalen, Holmestrand and Sørumsand with values measured in Sweden (Stockholm), Japan (Tokyo) and the United States (Dallas and Chicago) as a function of 10 year age-groups. Sample size in parenthesis.

Location	Oslo-Nydalen		Holmestrand		Sørumsand		Sweden *2		Japan *2		United States (both M+F) *3		
											Dallas	Chicago 1974	Chicago 1976
Age	M	F	M	F	M	F	M	F	M	F			
0- 9	0.30 (35)	0.28 (33)	0.47 (3)	0.64 (2)	0.17 (4)	0.34 (6)	0.17 (6)	0.22 (2)	0.35 (18)	0.42 (15)	0.37 (15)	0.50 (65)	0.41 (47)
10-19	0.19 (52)	0.22 (37)	0.35 (7)	0.37 (10)	0.26 (8)	0.33 (6)	0.18 (10)	- -	0.79 (29)	0.66 (28)	0.31 (8)	0.53 (38)	0.29 (40)
20-29	0.54 (1)	0.40 (2)	0.66 (2)	0.57 (8)	0.30 (1)	0.33 (1)	0.21 (10)	- -	0.80 (23)	0.90 (21)	0.38 (16)	0.63 (34)	0.56 (20)
30-39	0.43 (41)	0.53 (66)	0.99 (6)	0.89 (10)	0.56 (8)	0.45 (14)	0.28 (10)	- -	1.20 (45)	1.42 (41)	0.45 (7)	0.67 (47)	0.55 (44)
40-49	0.46 (36)	0.69 (28)	0.91 (6)	0.62 (12)	0.78 (5)	0.51 (16)	0.29 (10)	0.46 10	1.42 (52)	1.53 (73)	0.87 (16)	0.76 (15)	0.58 (13)
50-59	0.69 (4)	2.00 (3)	1.38 (4)	0.61 (8)	0.80 (4)	0.82 (6)	0.45 (10)	0.66 10	1.49 (48)	1.75 (52)	0.65 (24)	0.86 (18)	0.87 (19)
60-69	1.10 (2)	1.90 (3)	0.81 (9)	0.53 (12)	0.80 (2)	0.29 (1)	0.38 (10)	- -	1.68 (41)	1.38 (53)	- -	0.88 (6)	0.88 (6)
70-79	1.51 (6)	0.80 (1)	0.85 (5)	1.10 (2)	- -	- -	0.57 (11)	- -	1.65 (30)	1.47 (24)	- -	- -	- -
80-89	0.79 (5)	0.58 (11)	0.97 (3)	0.85 (10)	1.00 (1)	- -	0.36 (9)	- -	1.15 (6)	1.33 (8)	- -	- -	- -

Swedish values are for non-smokers only. United States and Norwegian values from both non-smokers and smokers.
*1 µg/l = 0.1124 X nmol/l
*2 Values from Kjellstrøm, 1979.
*3 Values from Kowal et al., 1979.

Table 21: Comparison of the medians of urinary cadmium values measured as µg/l[*1] in the inhabitants of Oslo and Sørumsand, with values measured in United States (Chicago and Dallas as a function of smoking habits. Sample sizes in parenthesis.

Smoking history	Oslo		Sørumsand		United States (both M and F)[*2]		
	M	F	M	F	Dallas	Chicago 1974	Chicago 1976
Never	0.40 (37)	0.46 (63)	0.56 (6)	0.45 (19)	0.40 (51)	0.54 (157)	0.43 (131)
Former	0.40 (23)	0.84 (17)	0.80 (4)	0.50 (10)	0.69 (21)	0.73 (25)	0.71 (23)
Present	0.70 (32)	0.58 (33)	1.00 (6)	0.51 (7)	0.65 (14)	0.85 (41)	0.57 (35)

*1 µg/l = 0.1124 X nmol/l
*2 Values from Kowal et al., 1979.

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APPENDIX I

Air Cadmium Values Used For Oslo-Nydalen,
Holmestrand and Sørumsand

Table I-1: Cadmium in air (ng/m^3) in Oslo - winter 1984. Outdoor cadmium values used in estimating personal exposure.

	N	E	S	W	Down-town Oslo	Back-ground Oslo	Wind direct *1	Wind speed m/s
Date	O.T. vei	Grefsen skole	Nydals-veien	Bakke-haug-veien	St. Olavs gate	Nordahl Bruns gate	Degrees measured Blindern	
Jan.								
24	1.05	0.25	11.58	0.48			50	4.0
25	1.37	1.20	24.10	1.36			80	3.5
26	1.09	0.68	10.69	1.21			80	3.5
27	0.55	0.89	10.79	0.49			70	4.5
28	0.27	0.25	4.36	0.71			40	4.0
29	0.49	0.74	3.00	0.42			50	4.0
30	0.82	0.82	12.12	7.21			70	3.5
31	0.98	0.44	2.61	5.85			70	3.5
Febr.								
1	0.94	0.77	2.48	1.01	2.20	1.15	45/190/80	4.5
2	0.72	0.39	1.54	29.90	1.35	2.45	60	3.5
3	0.38	0.50	0.78	9.06	2.25	2.30	50	4.0
4	0.38	0.63	0.82	1.01	0.60	<0.05	60/200	3.0
5	0.22	0.33	0.10	0.50	<0.05	<0.05	210	6.0
6	0.44	0.13	0.85	0.50	0.20	0.30	200/140	2.0
7	0.46	0.37	0.27	1.64	2.00	2.35	80/0/60	3.0
8	0.27	0.31	18.20	0.33	2.25	2.65	15/50	2.0
9	5.51	5.00	17.20	4.67	12.70	13.10	230/90/60	1.5
10	2.59	2.33	3.27	2.13	2.70	3.45	190/70	2.0
11	0.99	1.07	1.97	0.85	1.60	1.80	70/260	2.0
12	1.98	0.49	0.39	<0.07	0.20	0.20	230	2.0
13	4.93	1.51	1.21	0.98	1.50	1.80	250/40	2.5
14	10.87	6.37	9.56	4.22	2.50	2.75	unruly	
15	3.37	2.72	2.58	7.27	1.90	1.90	90/200	3.0
16	1.33	0.56	0.38	0.87	1.05	0.05	190/70	2.5
17	0.73	0.74	0.94	0.67	0.65	0.75	200	6.0
18	0.64	1.05	0.85	1.13	1.35	1.20	210	4.5
19	0.54	0.93	5.86	0.87	2.30	2.70	210/60	3.0
20	0.43	0.74	21.60	0.60	2.30	1.85	70	5.0
21	0.32		12.35	1.25	1.45	1.20	70	6.5
22	0.29		7.10	0.63	2.65	5.90	60	5.0
23	0.75		25.50	0.42	7.40	3.55	60	3.0
24	1.44		1.31	0.83	2.35	1.35	230	3.0
25	0.40		0.68	0.76	0.85	0.95	230/60	3.0
26	0.58		0.93	0.56	1.05	1.25	50/100/70	3.0
27	1.78		1.67	6.95	1.95	2.20	50/90/210	2.0
28	10.30	2.20	3.40	1.84	1.00	0.65	260	3.0
29	10.55	2.64	0.37	0.51	<0.05	<0.05	240	3.5
March								
1	2.98	4.55	2.94	0.37			250	6.5
2	<0.30	0.61	25.20	<0.40			250/50	7.5
3	6.55	2.56*3	0.77	0.95			250	4.0
$\bar{x}$*2	2.21	1.44	4.97	2.83	2.08	2.07		
Stand. dev.	3.17	1.59	7.09	5.69	2.45	2.49		
N	29	22	29	29	29	29		

*1 0^0 = winds from the North
*2 Mean for month of February only.
*3 Missing values excluded.

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Table I-2: Measured and estimated air cadmium concentrations (ng/m^3) in Holmestrand used in calculating individual air cadmium exposure in 1983 and 1984.

	HOLMESTRAND 1983		HOLMESTRAND 1984	
Date	Station 1	Station 2	Station 1	Station 2
April				
11	.06	.28		
12	.47	.13		
13	.29	.23		
14	.40	.33		
15	.33	.33		
16	.34	.33		
17	.58	.77		
18	.71	1.01	1.48	1.30
19	.41	-	.58	.78
20	.39	-	.99	.78
21	.41	-	1.46	.77
22	.46	-	5.56	.48
23	.34	-	.99	.52
24	.34	-	1.27	.65
25	1.11	-	1.27	.56
26	.58	.37	.59	<.28
27	.35	.63	1.06	.69
28	.30	.33	.73	.28
29	.54	.52	.76	.56
30	.29	.46	2.42	.97
May				
1	.18	.24	.73	1.53
2	.57	.28	.71	.56
3	.44	.34	.60	.99
4	.55	.42	.58	.71
5	.52	.37	.30	.56
6	.31	.34	.72	.55
7	.47	.23	.30	.54
8	.17	.34	.30	.68
9	.34	.34	.73	.28
10	.17	.24	.29	.56
11	.16	.24	.73	.28
12	.16	.23	<.30	<.28
13	.17	.23	.76	.28
14	.17	.28	.56	.28
15	.23	1.84	.88	<.27
16	1.24	-	1.57	.56
17	.15	.19	1.39	.71
18	.23	.13	<.29	.85
19	.15	.26	.61	2.30
20	.11	.33	.61	.56
21	.30	.21	.62	.99
22	.23	.51	.88	.56
23	-	-	-	.81

Table I-3: Measured and estimated air cadmium concentrations (ng/m^3) in Sørumsand used in calculating individual air cadmium exposure in 1983 and 1984.

	SØRUMSAND 1983		SØRUMSAND 1984	
Date	Station 1	Station 2	Station 1	Station 2
April				
14	.16	.19		
15	.26	.06		
16	.16	.17		
17	.48	.54	.37	.40
18	.23	.34	3.09	.85
19	.23	.25	2.32	.86
20	.33	.36	5.74	1.29
21	.15	1.75	1.08	.71
22	.27	.32	<.27	<.28
23	.16	28	.54	2.26
24	.14	.21	1.28	-
25	.33	38	.91	-
26	.16	.16	<.26	-
27	.53	.32	<.26	-
28	.25	.07	<.26	-
29	.05	.15	.66	-
30	.27	.19	1.72	-
May				
1	.17	.19	.65	.99
2	.05	.07	1.61	.71
3	.16	.06	.52	.58
4	.23	.16	1.17	.27
5	.13	.30	<.26	<.27
6	.15	-	.64	.81
7	.48	-	<.26	<.27
8	.22	-	.26	.28
9	.14	-	<.26	.79
10	.17	-	<.27	.96
11	.22	-	<.27	<.27
12	.05	-	<.27	.55
13	.19	.17	<.27	.27
14	.75	.06	<.27	.26
15	.43	.29	.27	.27
16	.24	.29	-	-
17	.59	.26	-	-
18	.16	.48	-	-
19	1.61	.58	-	-

APPENDIX II

Miscellaneous general information used in this report

1. Classification system for Social Class.
2. Eating habits of Norwegians

SOSIALGRUPPER

SOCIAL CLASSES

	Yrkesområde i Standard for yrkesgruppering i offentlig norsk statistikk *Occupation by Standard of Occupational Classifications*
Sosialgruppe A *Social class A*	00 Teknisk arbeid, 01 Kjemiker- og fysikerarbeid, 02 Biologisk arbeid, 03 Medisinsk arbeid, 05 Annet syke- og helsevernsarbeid, 06 Pedagogisk arbeid, 07 Religiøst arbeid, 08 Juridisk arbeid, 0X Annet arbeid innen teknisk, vitenskapelig, humanistisk og kunstnerisk arbeid, 10 Offentlig administrasjons- og forvaltningsarbeid, 11 Bedrifts- og organisasjonsledelse, 31 Salg av fast eiendom, tjenester, verdipapirer, forsikringer, brukte ting m.m.
Sosialgruppe B	09 Kunstnerisk og litterært arbeid, 20 Bokførings- og kassearbeid, 21 Stenografi- og maskinskrivingsarbeid, 29 Annet kontorarbeid, 30 Grossister og detaljister, 32 Handelsreisende- og agenturarbeid, 33 Handelsarbeid fra kontor, og detaljhandelsarbeid, 60 Skipsbefalarbeid, 62 Lufttrafikkarbeid, 63 Lokomotivførerarbeid, 65 Konduktørarbeid, 66 Trafikkledelse, 67 Post- og telekommunikasjonsarbeid, 74 Finmekanisk arbeid, 90 Sivilt overvåkings- og tryggingsarbeid, 96 Sport og idrett, 97 Fotografarbeid, 98 Begravelsesservice, X1 Militært arbeid
" C	04 Sykepleie- og annet pleiearbeid, 64 Vegtrafikkarbeid, 69 Annet transport- og kommunikasjonsarbeid, 71 Tilskjærings- og sømarbeid, 72 Skotøy- og lærvarearbeid, 75 Jern- og metallvarearbeid, 76 Elektroarbeid, 77 Trearbeid, 78 Malings- og bygningstapetseringsarbeid, 80 Grafisk arbeid, 82 Næringsmiddelarbeid, 87 Maskin- og motordrift, 92 Serveringsarbeid, 93 Vaktmester- og rengjøringsarbeid, 94 Hygiene og skjønnhetspleie, 99 Annet servicearbeid
" D	42 Viltstell og jakt, 43 Fiske- og fangstarbeid, 44 Skogsarbeid, 50 Gruve- og sprengningsarbeid, 51 Brønnborings- og diamantboringsarbeid, 52 Oppredningsarbeid, 59 Annet gruve- og sprengningsarbeid, 61 Dekks- og maskinmannskapsarbeid, 68 Postalt og annet budarbeid, 70 Tekstilarbeid, 73 Smelteverk-, metallverk- og støperiarbeid, 79 Annet bygge- og anleggsarbeid, 81 Glass-, keramikk- og teglarbeid, 83 Kjemisk prosessarbeid, treforedlings- og papirarbeid, 84 Tobakkarbeid, 85 Annet tilvirkingsarbeid, 86 Pakke- og emballeringsarbeid, 88 Laste-, losse- og lagerarbeid, 89 Diversearbeid innen industri-, bygge- og anleggsarbeid, 91 Hotell- og restaurantarbeid, husarbeid, 95 Vaske-, rense- og strykearbeid
" E	40 Arbeidsledelse i jord- og skogbruk, 41 Jordbruksarbeid, dyrerøkt

From: Yrke-Dødelighet

YRKESOMRADER PA ENGELSK

OCCUPATIONAL CLASSIFICATION IN ENGLISH

00 Technical work
01 Chemical and physical work
02 Biological work
03 Medical work
04 Nursing care
05 Other professional health and medical work
06 Pedagogical work
07 Religious work
08 Juridical work
09 Artistic and literary work
0X Other work in major group 0

10 Public administration
11 Administration of private enterprises and organizations

20 Book-keeping and cashier work
21 Stenography and typing work
29 Other clerical work

30 Working proprietors
31 Salesmen of real estate, securities, business-services, insurance etc.
32 Commercial travellers and manufacturers' agents work
33 Sales work from offices and retail sales work

40 Management in agriculture and forestry
41 Farmwork and livestock work
42 Game supervisors and game hunters
43 Fishing, whaling and sealing work
44 Forestry work

50 Mining and quarrying work
51 Well drilling and related work
52 Mineral treating work
59 Other mining and quarrying work

60 Ship officers and pilots
61 Deck and engine-room crew work
62 Air transport work
63 Railway engine drivers and firemen
64 Road transport work
65 Conductors, dispatchers and freight assistant work
66 Traffic supervising work
67 Postal and telecommunication work
68 Postal and other messenger work
69 Other transport and communication work

70 Textile work
71 Cutting and seam work
72 Shoe and leather work
73 Smelting, metallurgical and foundry work
74 Precision mechanical work
75 Iron and metalware work
76 Electrical work
77 Wood work
78 Painting and paperhanging work
79 Construction work not elsewhere classified

80 Graphic work
81 Glass, ceramic and clay work
82 Food and beverage work
83 Chemical and related process work
84 Tobacco work
85 Other production-process work
86 Packing and wrapping work
87 Stationary engine and motor-power work
88 Longshoremen and related freighthandlers
89 Labouring work not elsewhere classified

90 Public safety and protection work
91 Hotel, restaurant and domestic work
92 Waiting work
93 Building caretaking and charwork
94 Hygienical and beauty treatment work
95 Laundering, dry-cleaning and pressing work
96 Professional athletes and sportsmen etc.
97 Photographical work
98 Funeral service
99 Other service work
X1 Military work

From: Yrke-Dødelighet

Tabell 7.3. **Sammensetningen av matvareforbruket for gjennomsnittshusholdningen og pr. person. 1974—76. 1979-priser** *Consumption of food for the average household and per person. 1974-76. 1979 prices*

	Verdi *Value*		Mengde *Quantity*		Mengde pr. person pr. dag *Quantity per person per day*
	Kr *Kroner*	Prosent *Per cent*	Mengde-enhet *Quantity unit*	Kg/l *Kg/litre*	Gram/*ml.*
Matvarer i alt *Food, total*	13 275	100,0			
00 Mjøl, gryn og bakervarer *Flour, meal and bakery products*	1 193	9,0	kg	225,3	220,3
001 Mjøl og gryn *Flour and meal*	194	1,5	"	106,4	104,1
002 Kjeks, flatbrød og knekkebrød *Crispbread, biscuits etc.*	136	1,0	"	8,9	8,7
003 Brød *Bread*	534	4,0	"	93,4	91,3
004 Kaker *Cakes*	269	2,0	"	12,5	12,2
005 Makaroni og cornflakes *Macaroni and cornflakes*	60	0,5	"	4,1	4,0
01 Kjøtt, kjøttvarer og flesk *Meat, meat products and pork*	3 685	27,8	"	127,2	124,4
011 Ferskt kjøtt og flesk *Fresh meat and pork*	1 684	12,7	"	68,9	67,4
012 Saltet, røykt og tørket kjøtt og flesk *Salted, smoked and dried meat*	522	3,9	"	11,3	11,1
013 Kjøtthermetikk *Canned meat*	150	1,1	"	5,8	5,7
014 Andre kjøtt- og fleskevarer *Other meat and pork products*	1 253	9,4	"	39,1	38,2
015 Fryst kjøtt og kjøttvarer *Frozen meat and meat products*	76	0,6	"	2,1	2,1
02 Fisk og fiskevarer *Fish and fish products*	948	7,1	"	68,0	66,5
021 Fersk fisk *Fresh fish*	276	2,1	"	28,8	28,2
022 Fryst fisk *Frozen fish*	118	0,9	"	7,3	7,1
023 Saltet, røykt og tørket fisk og skalldyr *Salted, dried and smoked fish and shellfish*	198	1,5	"	11,8	11,5
024 Middagshermetikk *Canned dinner goods*	60	0,5	"	6,7	6,6
025 Småhermetikk *Sardines etc.*	125	0,9	"	3,4	3,3
026 Andre fiskevarer *Others fish products*	171	1,3	"	10,1	9,9
03 Mjølk, fløte, ost og egg *Milk, cream, cheese and eggs*	2 165	16,3	"	545,9[1]	533,9[1]
031 Mjølk *Milk*	953	7,2	liter	464,0	453,8
032 Fløte *Cream*	294	2,2	"	15,1	14,8
034 Ost *Cheese*	492	3,7	kg	25,2	24,6
035 Egg *Eggs*	426	3,2	"	27,2	26,6
04 Spisefett og -oljer *Edible oils and fats*	461	3,5	"	57,2	55,9
041 Smør *Butter*	145	1,1	"	9,2	9,0
042 Margarin og spiseolje *Margarine and edible oils*	316	2,4	"	47,9	46,8
05 Grønnsaker, frukt og bær *Vegetables, fruits and berries*	2 226	16,8	"	269,8	263,9
051 Kål og gulrøtter *Cabbage and carrots*	225	1,7	"	48,3	47,2
052 Andre friske grønnsaker *Other fresh vegetables*	304	2,3	"	28,6	28,0
053 Epler, pærer, plommer *Apples, pears and plums*	360	2,7	"	55,2	54,0
054 Sitrusfrukter, bananer og druer *Citrus fruits, bananas and grapes*	423	3,2	"	63,8	62,4
055 Tørket frukt og nøtter *Dried fruits and nuts*	116	0,9	"	6,4	6,3
056 Bær *Berries*	183	1,4	"	17,4	17,0
057 Konserverte grønnsaker *Preserved vegetables*	240	1,8	"	15,2	14,9
058 Konserverte frukt og bær *Preserved fruits and berries*	375	2,8	"	34,8	34,0
06 Poteter og varer av poteter *Potatoes and potato products*	469	3,5	"	204,8	200,3
061 Poteter *Potatoes*	375	2,8	"	200,0	195,6
062 Varer av poteter *Potato products*	94	0,7	"	4,8	4,7
07 Sukker *Sugar*	146	1,1	"	44,3	43,3
08 Kaffe, te, kakao og kokesjokolade *Coffee, tea, cocoa and chocolate*	970	7,3	"	22,6	22,1
081 Kaffe *Coffee*	862	6,5	"	20,3	19,9
082 Te *Tea*	50	0,4	"	0,5	0,5
083 Kakao og kokesjokolade *Cocoa and chocolate*	58	0,4	"	1,8	1,8
09 Andre matvarer *Other foods*	1 012	7,6	"	27,7	27,1
091 Spisesjokolade og drops *Chocolate and sugar confectionery*	362	2,7	"	9,1	8,9
092 Iskrem *Ice-cream*	166	1,3	"	8,3	8,1
093 Annet *Other*	484	3,6	"	10,2	10,0

[1] 1 l mjølk er regnet lik 1,03 kg.

From: Sosialt Utsyn 1980-SSB

APPENDIX III

Correlation coefficients between
measured variables in Oslo-Nydalen,
Holmestrand and Sørumsand
in children and in adults

Table III-1: Correlation matrix of pertinent data variables a) in children, b) in adults.

a) Children

Variables	U-Cd *2	Log U-Cd	Log A-Cd	LOCATION-Dum *1 Var 1	Var 2	Sex	Age	Soc. Cl.	Pass. smok.	Snow-eating
U-Cd	1.000									
Log U-Cd	0.830***	1.000								
Log A-Cd	-0.108	-0.134	1.000							
Loc Dum 1 *1	0.138	0.083	0.140*	1.000						
Loc Dum 2	-0.069	-0.140	0.787***	0.397***	1.000					
Sex	0.096	0.064	-0.115	0.045	-0.024	1.000				
Age	-0.206**	-0.164*	-0.085	0.101	-0.043	0.054	1.000			
Soc. Cl.	0.120	0.180**	0.218***	0.079	0.143*	-0.063	-0.234***	1.000		
Pass. Smok.	-0.063	0.027	-0.586***	-0.726***	-0.851***	-0.050	-0.043	-0.150**	1.000	
Snoweat	0.139**	0.198**	-0.769***	-0.057	-0.899***	0.055	0.041	-0.093	0.626***	1.000

Analyses done using DDPP (Jakobsen, 1982).
Probability values indicated: *<0.05; **<0.025, ***<0.001.
Sample sizes are variable and range from 176 to 229.
Children who admitted to smoking were removed prior to analysis.
*1 Location was analyzed using dummy variable having two digits Var 1 and 2. Oslo (0,+1), Holmestrand (+1,0), Sørumsand (-1,-1).
*2 U-Cd = Urinary cadmium/Urinary Creatinine; A-Cd = ambient cadmium exposure estimate.

Table III-1: continued

b) Adults

Variables	U-Cd *2	Log U-Cd	Log A-Cd	LOCATION-Dum *1 Var 1	Var 2	Sex	Age	Smoking	Lifetime Smoking	Soc. Cl.	Alc. Cons.	Beer	Wine	Spirit
U-Cd	1.000													
Log U-Cd	0.753***	1.000												
Log A-Cd	-0.081	-0.215***	1.000											
Loc dum 1 *1	0.157**	0.158**	-0.015	1.000										
Loc dum 2	-0.030	-0.128**	0.777***	0.284***	1.000									
Sex	0.100*	0.113**	-0.116**	0.006	-0.070	1.000								
Age	0.265***	0.359***	-0.326***	0.183***	-0.093*	-0.018	1.000							
Smoking	0.053	0.052	-0.002	-0.148***	-0.069	-0.120**	-0.066	1.000						
Life smok	0.088	0.142**	0.010	-0.017	-0.002	-0.081	-0.051	0.436***	1.000					
Soc. Cl.	0.305***	0.236***	-0.076	0.156***	0.080	0.076	0.425***	-0.057	-0.006	1.000				
Alc. Cons.	0.074	0.002	0.139**	-0.011	0.110**	-0.011	0.148***	-0.002	0.013	0.126**	1.000			
Beer	0.096	0.158**	-0.369***	0.033	-0.391***	0.117**	0.223***	-0.072	-0.061	0.207***	-0.104**	1.000		
Wine	0.098*	0.157**	-0.364***	0.037	-0.385***	0.129**	0.225***	-0.078	-0.066	0.210***	-0.105**	0.997***	1.000	
Spirit	0.100*	0.162***	-0.375***	0.396	-0.396***	0.115**	0.231***	-0.073	-0.062	0.210***	-0.103**	0.998***	0.997***	1.000

Analyses done using DDPP (Jakobsen, 1982).
Probability values indicated: *<0.05; **<0.025; ***<0.001
Sample sizes are variable and range from 399 to 477.
Occupationally exposed individuals are removed from analysis.
*1 Location was entered as a dummy variable using var 1 and 2: Oslo (0,+1); Holmestrand (+1,0); Sørumsand (-1,-1)
*2 2 U-Cd = Urinary cadmium/Urinary Creatinine; A-Cd = ambient cadmium exposure estimate.

APPENDIX 4

Results of additional analyses of variance with covariance

A) for U-Cd/U-Cr where covariates are entered before main factors in children and adults
B) for U-Cd without standardizing for U-Creatinine in adults
C) for U-Creatinine in adults

Table IV-1: Results of analysis of variance with covariance and of multiple classification analysis of the natural logarithm of urinary cadmium nmol/l/ urinary creatinine mmol/l in children, where covariates are processed before main effects.

ANALYSIS OF VARIANCE

CHILDREN 229 CASES PROCESSED; 99 CASES (43.2 %) MISSING

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
COVARIATES	6.869	2	3.435	2.978	.055
Age	2.695	1	2.695	2.337	.129
Ln Ambient Cad	5.281	1	5.281	4.579	.035
MAIN EFFECTS	6.730	8	.841	.729	.665
Location	2.751	2	1.376	1.193	.307
Sex	.040	1	.040	.035	.852
Passive Smoking	.549	1	.549	.476	.492
Social Class	3.283	4	.821	.711	.586
2-WAY INTERACTIONS	1.926	12	.160	.139	.999
Loc X Sex	.193	1	.193	.167	.683
Loc X Pas Smok	.010	1	.010	.009	.926
Loc X Soc Cl	.329	3	.110	.095	.963
Sex X Pas Smok	.203	1	.203	.176	.676
Sex X Soc Cl	.597	3	.199	.172	.915
Pas Smok X Soc Cl	.494	3	.165	.143	.934
EXPLAINED	15.525	22	.706	.612	.907
RESIDUAL	123.415	107	1.153		
TOTAL	138.939	129	1.077		

COVARIATE	REGRESSION COEFFICIENT ADJUSTED FOR ALL OTHER COVARIATES
AGE	-.046
LN OF AMBIENT CD EXP	-.458

MULTIPLE CLASSIFICATION ANALYSIS

GRAND MEAN = -1.61

VARIABLE + CATEGORY	N	UNADJUSTED DEV'N	ETA	ADJUSTED FOR INDEPENDENTS DEV'N	BETA	ADJUSTED FOR INDEPENDENTS + COVARIATES DEV'N	BETA
LOCATION							
NYDALEN	113	-.08				-.10	
HOLMESTRAND	16	.59				.64	
SØRUMSAND	1	.14				.62	
			.21				.24
SEX							
MALE	70	-.05				-.02	
FEMALE	60	.06				.02	
			.06				.02
EXP PASS SMOK							
NO	75	.05				.06	
YES	55	-.07				-.08	
			.05				.07
SOCIAL CLASS							
A	46	-.08				-.10	
B	46	.05				.18	
C	25	-.17				-.21	
D	12	.41				.14	
F	1	.91				.33	
			.17				.16
MULTIPLE R SQUARED							.098
MULTIPLE R							.313

Value are adjusted for all factors prior to assessing significance of covariates. Each covariate is adjusted for all other covariate before assessing significance.

Table IV-2: Results of analysis of variance with covariance and of multiple classification analysis of the natural logarithm of urinary cadmium nmol/l/ urinary creatinine mmol/l in adult men and women, where covariates are processed before main effects.

ANALYSIS OF VARIANCE

ADULT 477 CASES PROCESSED; 97 CASES (20.3 %) MISSING

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
COVARIATES	43.800	2	21.900	36.822	.001
Age	25.821	1	25.821	43.415	.001
Ln Ambient Cad	4.397	1	4.397	7.394	.007
MAIN EFFECTS	38.865	17	2.286	3.844	.001
Location	1.706	2	.853	1.434	.240
Sex	5.021	1	5.021	8.443	.004
Current smoking	22.028	5	4.406	7.408	.001
Social Class	7.741	5	1.548	2.603	.025
Alcohol consumption	6.114	4	1.528	2.570	.038
2-WAY INTERACTIONS	38.184	84	.455	.764	.927
Loc X Sex	1.660	2	.830	1.396	.249
Loc X Cur Smok	5.974	10	.597	1.005	.440
Loc X Soc Cl	7.625	10	.762	1.282	.240
Loc X Alc Cons	1.401	6	.234	.393	.883
Sex X Cur Smok	4.954	5	.991	1.666	.143
Sex X Soc Cl	2.078	5	.416	.699	.625
Sex X Alc Cons	1.010	3	.337	.566	.638
Cur Smok X Soc Cl	10.905	17	.641	1.079	.375
Cur Smok X Alc Cons	2.625	13	.202	.339	.985
Soc Cl X Alc Cons	5.869	13	.451	.759	.703
EXPLAINED	120.849	103	1.173	1.973	.001
RESIDUAL	164.151	276	.595		
TOTAL	285.001	379	.752		

COVARIATE	REGRESSION COEFFICIENT ADJUSTED FOR ALL OTHER COVARIATES
AGE	-.016
LN OF AMBIENT CD EXP	-.188

MULTIPLE CLASSIFICATION ANALYSIS

GRAND MEAN = -1.61

VARIABLE + CATEGORY	N	UNADJUSTED DEV'N	ETA	ADJUSTED FOR INDEPENDENTS DEV'N	BETA	ADJUSTED FOR INDEPENDENTS + COVARIATES DEV'N	BETA
LOCATION							
NYDALEN	217	-.16				-.00	
HOLMESTRAND	99	.36				.09	
SØRUMSAND	64	.00				-.14	
			.25				.09
SEX							
MALE	156	-.12				-.15	
FEMALE	224	.09				.10	
			.12				.14
CUR SMOK							
NEVER	159	-.18				-.28	
PREV	68	.09				.08	
OCCAS	38	-.07				.13	
1 - 9	34	.13				.19	
10 - 29	76	.24				.33	
30+	5	.46				.64	
			.20				.30
SOCIAL CLASS							
A	119	-.15				.11	
B	122	-.16				-.07	
C	67	.06				.16	
D	15	.41				.31	
F	14	.13				-.50	
G	43	.58				-.30	
			.28				.21
ALCOHOL CONSUMPTION							
NEVER	74	.17				.16	
OCCAS	132	.21				.11	
LITTLE	139	-.27				-.18	
MODERATE	34	-.05				-.05	
DAILY	1	-.69				-.16	
			.26				.17
MULTIPLE R SQUARED							.290
MULTIPLE R							.539

Values are adjusted for all factors prior to assessing significance of covariates. Each covariate is adjusted for all other covariate before assessing significance.

Table IV-3: Results of analysis of variance with covariance and of multiple classification analysis of the natural logarithm of urinary cadmium (nmol/l) in adult men and women.

ANALYSIS OF VARIANCE

ADULT 477 CASES PROCESSED: 97 CASES (20.3 %) MISSING

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	47.983	17	2.823	5.049	.001
Location	8.120	2	4.060	7.263	.001
Sex	.514	1	.514	.920	.338
Current smoking	16.188	5	3.238	5.792	.001
Social Class	8.374	5	1.675	2.996	.012
Alcohol consumption	4.814	4	1.204	2.153	.075
COVARIATES	9.277	2	4.638	8.298	.001
Age	8.223	1	8.223	14.711	.001
Ln Ambient Cad	.572	1	.572	1.024	.313
2-WAY INTERACTIONS	38.810	84	.462	.827	.848
Loc X Sex	3.710	2	1.855	3.318	.038
Loc X Cur Smok	6.454	10	.645	1.155	.322
Loc X Soc Cl	7.846	10	.785	1.404	.178
Loc X Alc Cons	2.383	6	.397	.710	.641
Sex X Cur Smok	4.515	5	.903	1.615	.156
Sex X Soc Cl	2.258	5	.452	.808	.545
Sex X Alc Cons	1.573	3	.524	.938	.423
Cur Smok X Soc Cl	11.404	17	.671	1.200	.264
Cur Smok X Alc Cons	2.334	13	.180	.321	.989
Soc Cl X Alc Cons	7.208	13	.554	.992	.459
EXPLAINED	96.070	103	.933	1.669	.001
RESIDUAL	154.279	276	.559		
TOTAL	250.350	379	.661		

COVARIATE	REGRESSION COEFFICIENT ADJUSTED FOR ALL OTHER COVARIATES
AGE	.014
LN OF AMBIENT CD EXP	-.130

MULTIPLE CLASSIFICATION ANALYSIS

GRAND MEAN = 1.57

VARIABLE + CATEGORY	N	UNADJUSTED DEV'N	ETA	ADJUSTED FOR INDEPENDENTS DEV'N	BETA	ADJUSTED FOR INDEPENDENTS + COVARIATES DEV'N	BETA
LOCATION							
NYDALEN	217	-.18		-.12		-.03	
HOLMESTRAND	99	.36		.26		.14	
SØRUMSAND	64	.04		.00		-.10	
			.28		.20		.11
SEX							
MALE	156	-.05		-.05		-.06	
FEMALE	224	.04		.03		.04	
			.05		.05		.07
CUR SMOK							
NEVER	159	-.19		-.24		-.26	
PREV	68	.06		.08		.04	
OCCAS	38	-.00		.12		.15	
1 - 9	34	.21		.28		.25	
10 - 29	76	.21		.22		.27	
30+	5	.59		.54		.66	
			.22		.27		.29
SOCIAL CLASS							
A	119	-.09		-.01		.09	
B	122	-.13		-.15		-.07	
C	67	.02		.01		.09	
D	15	.33		.19		.22	
F	14	.24		-.05		-.27	
G	43	.41		.38		-.18	
			.23		.19		.15
ALCOHOL CONSUMPTION							
NEVER	74	.12		.10		.13	
OCCAS	132	.18		.12		.10	
LITTLE	139	-.21		-.15		-.14	
MODERATE	34	-.07		-.07		-.09	
DAILY	1	-.62		-.72		-.38	
			.22		.16		.15
MULTIPLE R SQUARED					.192		.229
MULTIPLE R					.438		.478

Table IV-4: Results of analysis of variance with covariance and of multiple classification analysis of the natural logarithm of a creatinine (mmol/l) in adult men and women.

ANALYSIS OF VARIANCE

ADULT 477 CASES PROCESSED; 97 CASES (20.3 %) MISSING

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	4.190	17	.246	2.211	.004
Location	.207	2	.103	.928	.397
Sex	1.178	1	1.178	10.569	.001
Current smoking	.470	5	.094	.843	.520
Social Class	1.317	5	.263	2.363	.040
Alcohol consumption	.479	4	.120	1.075	.369
COVARIATES	2.236	2	1.118	10.030	.001
Age	2.225	1	2.225	19.065	.001
Ln Ambient Cad	.001	1	.001	.012	.914
2-WAY INTERACTIONS	12.004	84	.143	1.282	.071
Loc X Sex	.412	2	.206	1.850	.159
Loc X Cur Smok	1.026	10	.103	.921	.514
Loc X Soc Cl	.939	10	.094	.843	.588
Loc X Alc Cons	.955	6	.159	1.427	.204
Sex X Cur Smok	.229	5	.046	.412	.841
Sex X Soc Cl	.601	5	.120	1.078	.373
Sex X Alc Cons	.287	3	.096	.859	.463
Cur Smok X Soc Cl	2.550	17	.150	1.346	.164
Cur Smok X Alc Cons	1.263	13	.097	.872	.583
Soc Cl X Alc Cons	1.368	13	.105	.944	.508
EXPLAINED	18.430	103	.179	1.605	.001
RESIDUAL	30.764	276	.111		
TOTAL	49.195	379	.130		

COVARIATE	REGRESSION COEFFICIENT ADJUSTED FOR ALL OTHER COVARIATES
AGE	-.007
LN OF AMBIENT CD EXP	-.006

MULTIPLE CLASSIFICATION ANALYSIS

GRAND MEAN = -1.57

VARIABLE + CATEGORY	N	UNADJUSTED DEV'N	ETA	ADJUSTED FOR INDEPENDENTS DEV'N	BETA	ADJUSTED FOR INDEPENDENTS + COVARIATES DEV'N	BETA
LOCATION							
NYDALEN	217	-.01		-.02		-.04	
HOLMESTRAND	99	.00		.02		.05	
SØRUMSAND	64	.04		.04		.14	
			.05		.07		.11
SEX							
MALE	156	.07		.07		.08	
FEMALE	224	-.05		-.05		-.06	
			.17		.16		.19
CUR SMOK							
NEVER	159	-.01		.01		.02	
PREV	68	-.04		-.05		-.04	
OCCAS	38	.06		.04		.03	
1 - 9	34	.08		.05		.06	
10 - 29	76	-.02		-.03		-.05	
30+	5	.12		.07		.02	
			.11		.10		.10
SOCIAL CLASS							
A	119	.06		.03		-.02	
B	122	.02		.03		-.00	
C	67	-.04		-.03		-.07	
D	15	-.09		-.07		-.09	
F	14	.10		.13		.23	
G	43	-.17		-.14		.12	
			.20		.17		.19
ALCOHOL CONSUMPTION							
NEVER	74	-.05		-.01		-.03	
OCCAS	132	-.03		-.03		-.02	
LITTLE	139	.06		.05		.04	
MODERATE	34	-.01		-.06		-.04	
DAILY	1	.07		-.06		-.22	
			.12		.10		.09
MULTIPLE R SQUARED					.085		.131
MULTIPLE R					.292		.361

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TITTEL Cadmium in urine in inhabitants of Oslo-Nydalen, Holmestrand and Sørumsand as a function of air cadmium and other socio-economic factors.		PROSJEKTLEDER J. Clench-Aas	
		NILU PROSJEKT NR. N-8366	
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3 STIKKORD (à maks. 20 anslag)

Urinary cadmium	smoking habits	alcohol consumption

REFERAT (maks. 300 anslag, 7 linjer)
Nivåer av kadmium i urin var målt hos menn, kvinner og barn i Oslo-Nydalen (området med industriel belastning), Holmestrand og Sørumsand. Tross høyere verdier av kadmium i luft i Oslo-Nydalen, var ikke urinverdier høyere der. De faktorene som best forklarte de målte verdier var alder, kjønn, røyke-vaner og bruk av alkohol.

TITLE Cadmium in urine in inhabitants of Oslo-Nydalen, Holmestrand and Sørumsand as a function of air cadmium and other socio-economic factors.

ABSTRACT (max. 300 characters, 7 lines)
Urinary cadmium was measured in men, women and children in Oslo-Nydalen (exposed to industrial cadmium emission), Holmestrand and Sørumsand (both controls). Despite higher ambient values of cadmium in Oslo-Nydalen than in the two control areas no significant differences were measured between the three sites in concentrations of cadmium in the urine that can be attributed to ambient cadmium levels. Age, smoking habits, alcohol consumption and social class were the primary factors influencing levels of urinary cadmium in these populations.

* Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
Kan ikke utleveres C