From:
Sent: do, 27 dec 2018 09:47:55 +01:00
To:
Subject: Houtstook Schone Lucht Akkoord 2019 - Uw input hiervoor is nodig
Attachments: Houtrook_SLA2019.jpg
PDF-UFP_study.pdf

Goedenmorgen geachte gemeente en griffie,

Mag ik u deze studieresultaten over ultrafijnstof met uw gemeenteraad en B&W delen en ook het verzoek
om Houtstook ten strengste te ontraden in het Schone Lucht Akkoord 2019, waarbij u als één van de partijen, direct of indirect, bij betrokken bent.

Er is maar één middel dat werkt om aan de houtstookproblemen een eind te maken en dat is een verbod op houtstook.

Vaak hoor je Nee de tijd is hier nog niet rijp voor. Dat klopt niet de tijd is altijd rijp voor een houtstookverbod want de maat is vol en als wij dat willen dan lukt het ook.

Via uw achterban of uw partij is het de hoogste prioriteit om dit voorgoed op te lossen. Zo maar aanmodderen en gedogen leidt nooit tot een schonere lucht in woonwijken zolang
we massaal van het gas af gaan de komende jaren en houtstook als goedkope oplossing kunnen oppakken. Ook die zogenaamd schone pelletkachel is een illusie, want ultrafijne stof
is ontzettend gevaarlijk. Een stille moordenaar..

Bewustzijnscampagnes zijn een wassen neus en lossen niets op.

Laten we onze verantwoordelijkheid nemen en hier aan bijdragen zodat het houtstookverbod er echt komt.

vr groet

A Section 508–conformant HTML version of this article is available at https://doi.org/10.1289/EHP3047.

Long-Term Exposure to Ultrafine Particles and Incidence of Cardiovascular and Cerebrovascular Disease in a Prospective Study of a Dutch Cohort

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Background: There is growing evidence that exposure to ultrafine particles (UFP; particles smaller than 100 nm) may play an underexplored role in the etiology of several illnesses, including cardiovascular disease (CVD).

Objectives: We aimed o investigate the relationship between long-term exposure to ambient UFP and incident cardiovascular and cerebrovascular disease (CVA). As a secondary objective, we sought to compare effect estimates for UFP with those derived for other air pollutants, including estimates from two-pollutant models.

Methods: Using a prospective cohort of 33,831 Dutch residents, we studied the association between long-term exposure to UFP (predicted via land use regression) and incident disease using Cox proportional hazard models. Hazard ratios (HR) for UFP were compared to HRs for more routinely monitored air pollutants, including particulate matter with aerodynamic diameter ≤ 10 μm (PM_{10}), PM with aerodynamic diameter ≤ 2.5 ($PM_{2.5}$), and NO_2.

Results: Long-term UFP exposure was associated with an increased risk for all incident CVD [HR = 1.18 per 10,000 particles/cm^3; 95% confidence interval (CI): 1.03, 1.34], myocardial infarction (MI) (HR = 1.34; 95% CI: 1.00, 1.79), and heart failure (HR = 1.76; 95% CI: 1.17, 2.66). Positive associations were also estimated for NO_2 (HR for heart failure = 1.22; 95% CI: 1.01, 1.48 per 20 μg/m^3) and coarse PM (PM_{coarse}; HR for all CVD = 1.21; 95% CI: 1.01, 1.45 per 10 μg/m^3). CVD was not positively associated with $PM_{2.5}$ (HR for all CVD = 0.95; 95% CI: 0.75, 1.28 per 5 μg/m^3). HRs for UFP and CVAs were positive, but not significant. In two-pollutant models (UFP + NO_2 and UFP + PM_{coarse}), positive associations tended to remain for UFP, while HRs for PM_{coarse} and NO_2 generally attenuated towards the null.

Conclusions: These findings strengthen the evidence that UFP exposure plays an important role in cardiovascular health and that risks of ambient air pollution may have been underestimated based on conventional air pollution metrics. https://doi.org/10.1289/EHP3047

Introduction

Long-term exposure to ambient air pollution has been linked to multiple health outcomes, including mortality, malignant disease, and cardiovascular disease (CVD) (Beelen, Raaschou-Nielsen et al. 2014; Beelen et al. 2015; Cesaroni et al. 2014; WHO 2017). Particulate matter with aerodynamic diameter ≤ 10 μm (PM_{10}) can be deposited within the respiratory tract, while particles ≤ 2.5 ($PM_{2.5}$) have a higher fractional deposition within alveoli, resulting in tissue inflammation, oxidative stress, and systemic health effects (Brown et al. 2013; Meng et al. 2016).

There is growing evidence that ultrafine particles (UFPs; particles smaller than 100 nm) may contribute significantly to the health effects associated with PM. Due to their relatively small size, UFPs make up a small percentage of total PM mass and are thus poorly reflected by conventional PM measurements (HEI 2013). Further, owing to their small size fraction, UFPs contain a high surface area–to–mass ratio, giving them a high potential for translocation and interaction with tissue, resulting in oxidative stress and inflammation within extrapulmonary organs (HEI 2013; Stone et al. 2016). The bulk [albeit not all (Jordakieva et al. 2018)] of experimental animal and human studies have reported that UFP exposure is associated with atherosclerotic plaque formation, oxidative stress, increased inflammatory and procoagulant biomarkers, reduced coronary circulation, elevated blood pressure, and autonomic imbalance, suggesting that UFP exposure may play an important role in cardiovascular health (Aguilera et al. 2016; Bai et al. 2018; Chung et al. 2015; Keebaugh et al. 2015; Lane et al. 2016; Liu et al. 2018).

Despite the growing experimental evidence, few epidemiological studies on the effects of UFP exposure have been performed. In general, the few studies thus far have typically focused upon short-term exposures or upon individuals with existing illness and have had inconsistent findings. In a study of short-term UFP exposure and mortality patterns, Lanzinger et al. (2016a) reported a 9.9% increase in respiratory mortality [95% confidence interval (CI): −6.3, 28.8%) associated with a 2,750-particle/m^3 increase in UFP, but no increase in cardiovascular mortality (percentage change: −0.2%; 95% CI: −5.5, 5.4% per 2,750 particles/m^3). This was also reflected in their study of hospital admissions (Lanzinger et al. 2016b), where they reported a 3.4% increase in pooled relative risk (RR) (95% CI: −1.7, 8.8%) per 2,750 particles/m^3 of UFP for respiratory admissions but no association with cardiovascular admissions (risk estimate: −0.1%; 95% CI: −2.6, 2.4% per 2,750 particles/m^3). Contrastingly, von Klot et al. (2005) reported an increased risk of hospital readmission with a cardiac event (RR: 1.026; 95% CI: 1.005, 1.048 per 10,000 particles/m^3) among myocardial infarction (MI) survivors. Less is known regarding long-term exposure, which may be more relevant for the development of

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models were developed, each with increasing levels of adjustment. Model 1 included only sex and year of enrollment; model 2 added smoking status (never, former, or current), smoking intensity and duration, fruit and vegetable intake, alcohol intake, BMI, educational level (low, medium, or high), and marital status. Model 3 added area-level socioeconomic information. Missing data for confounding variables [information on one or more confounder was missing for ~8% ($n=2,742$) of the study participants] were imputed via multiple imputation by chained equation (Buuren and Groothuis-Oudshoorn 2011). HRs are presented for increments of exposure used in previous studies published within ESCAPE: 5 $\mu g/m^3$ for $PM_{2.5}$ and PM_{coarse}, 10 $\mu g/m^3$ for PM_{10}, 10,000 particles/m^3 for UFP, $1 \times 10^{-5} m^{-1}$ for $PM_{2.5}$ absorbance, 20 $\mu g/m^3$ for NO_x, and 10 $\mu g/m^3$ for NO_2.

Sensitivity analysis was performed via addition of urban/rural status to the main model (a rural city was defined as having <100,000 inhabitants). To assess the potential influence of exposure misclassification due to residential mobility, we also performed a sensitivity analysis restricted to participants who did not move during follow-up among the subset of the EPIC cohort ($n=12,418$) who had full moving histories. To evaluate the influence of missing data imputation, the analysis was also repeated among those with complete confounder information only ($n=31,089$).

Posthoc Analyses

Additional posthoc analyses were performed following the primary analysis. First, we applied a ridge penalty to regression models of CVD incidence to further evaluate mutually adjusted associations for the highly correlated pollutants UFP and NO_2 ($r=0.80$) and UFP and PM_{coarse} ($r=0.74$). Second, to investigate limitations secondary to the back extrapolation of data prior to the year of UFP model validation (2005), we restricted analyses to participants who were alive (and disease free) from 2005 onward.

Results

Study Participants

A total of 40,011 individuals were enrolled, of whom 38,707 (97%) consented for linkage to disease records. We excluded 507 people with missing vital status and/or cause-of-death information, 3,927 people for whom pollutant predictions were unable to be performed due to incomplete residential information, and 442 people with prevalent CVD, resulting in 33,831 eligible participants.

The average age of participants at recruitment was 50 y [± standard deviation of 11 y] (Table 1). Each participant contributed an average of 15 y of follow-up (± 2.4 y; ~450,000 person-years). As the Prospect cohort was exclusively female, the

Table 1. Overview of study population demographics at baseline and modeled pollutants.

Characteristic	*n* (%), or mean ± SD (min - max)	No. missing values[a]
Population demographics		
No. of participants	33,831	—
Age at baseline	50 ± 11	0
Years of follow-up	15 ± 2.4	0
Gender		0
Male	7,846 (23)	—
Female	25,985 (77)	—
Smoking status		137
Current	10,025 (30)	—
Former	10,837 (32)	—
Never	12,832 (38)	—
Smoking intensity (cigarettes/d)	8 ± 10	1,898
Smoking duration (y)	15 ± 15	639
Fruit intake (g/d)	201 ± 137	135
Vegetable intake (g/d)	131 ± 52	135
Body mass index (kg/m^2)	25 ± 4	0
Marital status		176
Single	4,789 (14)	—
Married/living with partner	24,328 (72)	—
Divorced/separated	2,646 (8)	—
Widowed	1,892 (6)	—
Education level		219
Low (primary school)	5,678 (17%)	—
Medium (secondary school)	21,426 (64%)	—
High (university)	6,508 (19%)	—
Percentage of people with low income in neighborhood	39 ± 8	608
Residing in urban or rural city at enrollment[c]		0
Urban	15,674 (46%)	—
Rural	18,157 (54%)	—
Residential history available	12,418	—
Moved residence	3,741 (30%)	—
Did not move residence	8,677 (70%)	—
Estimated annual pollutant exposures at subject recruitment[b]		—
$PM_{2.5}$	17 ± 0.56 (15.4–20.95)	0
PM_{coarse}	9 ± 0.91 (7.6–14.2)	0
PM_{10}	25 ± 1.4 (23.7–34.7)	0
UFP (particles/cm^3)	11,110 ± 2,400 (7.190–29,470)	0
$PM_{2.5}$ absorbance ($10^{-5} m^{-1}$)	1.4 ± 0.21 (0.9–2.9)	0
NO_x	38 ± 11 (21.4–108.7)	0
NO_2	25 ± 6 (13– 62)	0

Note: —, data not available; PM, particulate matter; PM_{coarse}, PM between 2.5 and 10 μm; UFP, ultrafine particles <100 nm.
[a]Missing values are imputed via multiple chained imputation (MICE).
[b]Measurements are in $\mu g/m^3$ unless stated otherwise.
[c]A rural city is defined as having a population under 100,000.

Table 3. Hazard ratio (95% confidence interval) associations between annual average air pollutant exposures and incident cardiovascular disease.

Pollutants	All cardiovascular disease 4,304 events	Coronary heart disease 2,399 events	Myocardial infarctions 797 events	Heart failure 369 events
Single-pollutant models	—	—	—	—
$PM_{2.5}$	0.98 (0.75, 1.28)	0.80 (0.55, 1.15)	0.83 (0.44, 1.57)	0.44 (0.16, 1.20)
PM_{coarse}	1.21 (1.01, 1.45)	1.26 (0.99, 1.60)	1.50 (1.01, 2.21)	1.70 (0.90, 3.21)
PM_{10}	1.20 (0.96, 1.50)	1.14 (0.85, 1.53)	1.27 (0.77, 2.09)	2.09 (0.99, 4.40)
UFP	1.18 (1.03, 1.34)	1.12 (0.94, 1.33)	1.34 (1.00, 1.79)	1.76 (1.17, 2.66)
$PM_{2.5}$ absorbance	1.07 (0.92, 1.23)	0.97 (0.80, 1.18)	1.12 (0.80, 1.56)	1.16 (0.70, 1.90)
NO_x	1.03 (0.98, 1.09)	1.02 (0.95, 1.10)	1.10 (0.97, 1.25)	1.13 (0.93, 1.37)
NO_2	1.04 (0.98, 1.10)	1.04 (0.97, 1.12)	1.12 (0.99, 1.26)	1.22 (1.01, 1.48)
Two-pollutant models	—	—	—	—
UFP + $PM_{2.5}$	—	—	—	—
UFP	1.28 (1.09,1.49)	1.27 (1.04, 1.57)	1.59 (1.13, 2.24)	3.10 (1.89, 5.10)
$PM_{2.5}$	0.74 (0.54, 1.02)	0.61 (0.40, 0.94)	0.51 (0.24, 1.05)	0.11 (0.03, 0.36)
UFP + PM_{coarse}	—	—	—	—
UFP	1.14 (0.95, 1.37)	0.99 (0.77, 1.27)	1.16 (0.76, 1.77)	1.84 (1.04, 3.26)
PM_{coarse}	1.06 (0.83, 1.37)	1.27 (0.91, 1.78)	1.30 (0.74, 2.28)	0.90 (0.37, 2.19)
UFP + PM_{10}	—	—	—	—
UFP	1.25 (1.01, 1.56)	1.16 (0.86, 1.57)	1.67 (1.01, 2.75)	1.94 (0.96, 3.92)
PM_{10}	0.88 (060, 1.28)	0.93 (0.56, 1.55)	0.63 (0.26, 1.50)	0.80 (0.22, 2.92)
UFP + $PM_{2.5abs}$	—	—	—	—
UFP	1.42 (1.13, 1.77)	1.49 (1.10, 2.01)	1.87 (1.12, 3.10)	3.98 (1.97, 8.04)
$PM_{2.5abs}$	0.78 (0.60, 1.00)	0.68 (0.48, 0.95)	0.63 (0.35, 1.13)	0.30 (0.13, 0.73)
UFP + NO_x	—	—	—	—
UFP	1.26 (1.04, 1.51)	1.17 (0.91, 1.51)	1.31 (0.85, 2.03)	2.10 (1.17, 3.79)
NO_x	0.96 (0.89, 1.04)	0.97 (0.87, 1.09)	1.01 (0.83, 1.22)	0.86 (0.67, 1.18)
UFP + NO_2	—	—	—	—
UFP	1.28 (1.04, 1.59)	1.09 (0.82, 1.47)	1.22 (0.74, 2.02)	1.75 (0.89, 3.45)
NO_2	0.96 (0.86, 1.05)	1.01 (0.90, 1.14)	1.05 (0.85, 1.28)	1.00 (0.74, 1.37)

Note: PM, particulate matter; PM_{coarse}, PM between 2.5 and 10 μm; UFP, ultrafine particles <100 nm. All models adjusted for: smoking status (including number of cigarettes and duration of smoking), diet (intake of fruit and vegetables), alcohol consumption, BMI, recruitment year, gender, marital status, education level, and area-level economic status. Hazard ratios (HRs) are presented for the following increments: 5 $\mu g/m^3$ for $PM_{2.5}$, 5 $\mu g/m^3$ for PM_{coarse}, 10 $\mu g/m^3$ for PM_{10}, 10,000 particles/cm^3 for UFP, $1 \times 10^{-5} m^{-1}$ for $PM_{2.5}$ absorbance, 20 $\mu g/m^3$ for NO_x, and 10 $\mu g/m^3$ for NO_2.

Cerebrovascular diseases. In single-pollutant models, an increase in UFP exposure of 10,000 particles/cm^3 was associated with an HR of 1.11 (95% CI: 0.88, 1.41) for all incident CVAs, 1.07 (95% CI: 0.80, 1.44) for the ischemic subtype, and 1.48 (95% CI: 0.88, 2.51) for the hemorrhagic subtype (Table 4). For $PM_{2.5}$, an increase in exposure of 5 $\mu g/m^3$ was associated with an HR of 1.13 (95% CI: 0.69, 1.83) for all cerebrovascular events and 1.88 (95% CI: 0.66, 5.39) for hemorrhagic events. Exposure to PM_{coarse} was also associated with an increased risk of all events (HR = 1.14; 95% CI: 0.80, 1.61), including the ischemic (HR = 1.22; 95% CI: 0.79, 1.86) and hemorrhagic (HR = 1.91; 95% CI: 0.90, 4.04) subtypes. Exposures to NO_x and NO_2 were associated with elevated, albeit nonsignificant risks of hemorrhagic CVA (HR = 1.15; 95% CI: 0.91, 1.44 for NO_x, and 1.09; 95% CI: 0.86, 1.37 for NO_2).

In two-pollutant models, associations of UFP with all incident CVA and hemorrhagic CVA tended to remain positive, while corresponding estimates for the second pollutant reduced to the null or become negative (Table 4). For example, when UFP was paired with $PM_{2.5}$, the HR for $PM_{2.5}$ and cerebrovascular incidence became null (HR = 1.00; 95% CI: 0.55, 1.80), but remained elevated for UFP (HR = 1.11; 95% CI: 0.83, 1.48). However, when UFP was paired with PM_{coarse}, HRs for all incident cerebrovascular and hemorrhagic disease reduced toward the null for both pollutants. For ischemic events, the association with UFP reduced to the null value, while the HR for PM_{coarse} increased slightly (HR = 1.27; 95% CI: 0.71, 2.29).

Sensitivity analyses. The fully adjusted HRs for UFP (i.e., adjusted for smoking status, duration, and intensity; diet; alcohol consumption; BMI; recruitment year; gender; marital status; education level; and area-level economic status; Tables 3 and 4) were generally slightly lower than the less adjusted HRs (i.e., positive findings in the less adjusted models moved closer to the null, and negative findings became more so as the level of adjustment increased; Tables S3 and S4) and similar to estimates from fully adjusted models restricted to those with complete confounder information ($n = 31,089$). Findings were generally robust across multiple sensitivity analyses, including adjustment for rural status and restricting analyses to those who did not move home during the follow-up period. Inclusion of rural status in models resulted in a reduction in the hazard for UFP exposure and CHD towards the null value; however, HRs for UFP and the other cardiovascular outcomes remained robust. HRs for subjects who did not move during follow-up were generally consistent with estimates for the overall population.

Posthoc Analyses

Estimates for UFP and NO_2 from bipollutant CVD models with a ridge penalty applied showed null HRs for NO_2 that were consistent with the unpenalized bipollutant model HRs, while HRs for UFP remained positive but were attenuated slightly towards the null (Table S5). When a ridge penalty was applied to the UFP and PM_{coarse} bipollutant model, HRs for UFP and PM_{coarse} remained positive but were attenuated towards the null. For heart failure, the bipollutant model HR for PM_{coarse} (HR = 0.90; 95% CI: 0.37, 2.19) became positive (although it remained nonstatistically significant; HR = 1.12; 95% CI: 0.66, 1.89). Effect estimates for UFP among participants who were alive and disease free in 2005 ($n = 30,685$) were generally consistent with the main analysis (Tables S3 and S4). However, the HR for MI (HR = 2.03; 95% CI: 1.29, 3.22) was stronger, while the HR for heart failure (HR = 1.15; 95% CI: 0.61, 2.19) was closer to the null than corresponding HRs from the main model.

Discussion

Exposure to ambient air pollution represents a significant public health concern across the globe. Adequately representing the complex mixture of ambient air pollution is key for the planning

have reported associations with short-term but not long-term exposure to coarse PM (Adar et al. 2014; Brunekreef and Forsberg 2005; Hoek et al. 2013). In two-pollutant models with UFP, the observed HRs for coarse PM reduced towards the null for all CVD and heart failure while remaining positive for CHD and myocardial infarction, suggesting that coarse PM and UFP may, to some extent, have independent effects on cardiovascular health. As with NO_2, coarse PM was moderately correlated with UFP ($r = 0.74$), but estimates from ridge regression were generally consistent with the unpenalized models, with some attenuation to the null. HRs were also positive (albeit nonsignificant) for PM_{10} and $PM_{2.5}$ absorbance, consistent with findings reported by Cesaroni et al. (2014) and Fuks et al. (2017), while Atkinson et al. (2013) reported that incident CVD was positively associated with $PM_{2.5}$ absorbance, but not PM_{10}.

Strengths and Limitations

The current study represents a large, well-established cohort with sufficient follow-up to adequately study CVD risk. Assigning historical exposures can represent a challenge, especially where exposures are measured and modeled decades after the period for which they are assigned. Montagne et al. (2015) previously reported an R^2 value of 0.36 when using currently derived models to predict measurements collected 10 y previously, indicating that although absolute levels may change [within Europe, air quality has generally improved (European Environment Agency 2016)], the spatial distributions remain relatively stable over time. Despite this, some exposure uncertainty remains, as the ability to further verify the historical assignment of UFP measurements is limited by a lack of routine monitoring data for UFP. When we restricted our dataset to participants who were alive (and disease free) from 2005 onwards (i.e., when model validation data were available), findings were consistent with the main analysis. It is important to note that we are unable to fully validate the pertinent time period between exposure and outcome—a limitation that applies to all of the pollutants evaluated.

An additional limitation is that exposures were assigned solely at addresses assigned at baseline (i.e., enrollment). The extent to which residential mobility might have influenced our findings is dependent on the numbers and characteristics of participants who changed addresses during the study period. Findings for UFP were comparable to the primary analysis when restricted to participants who had complete residential history data and did not move after baseline. Therefore, we believe it is unlikely that associations between UFP and cardiovascular outcomes were a consequence of exposure misclassification due to residential mobility. An additional consideration is that although site selection and LUR model development for UFP was performed following procedures consistent with those used in the ESCAPE project [so as to maximize transferability of models and predictions (van Nunen et al. 2017)], exposure estimates for conventional pollutants and UFP were derived from separate campaigns with a different number of measurement locations, duration, and times of measurements, potentially limiting comparability of LUR predictions.

Measurements of UFP were collected only during daytime hours, with rush hours excluded to reduce the influence of peak exposures and enhance comparability between different road segments. Therefore, UFP exposures may have been misclassified for road segments where nighttime and rush hour concentrations were not correlated with concentrations during the 0900–1600 hours measurement periods. For a previous study of differences between air pollution concentrations measured at background monitors and within and outside individual homes, Hoek et al. (2008) collected hourly measurements of particle number (PN) concentrations for particles from 7 nm–3 μm in diameter (thus including UFP) using CPC3022A instruments (TSI) placed outside 50 homes across the city of Amsterdam, including 28 urban background and 22 high-traffic locations. We used this previously collected data to compare the differences in average PN concentrations between urban background and traffic areas based on hourly measurements taken over 24 h versus hourly measurements taken between 0900 and 1600 hours. Average PN concentrations at urban background and traffic sites were 24,654 and 41,598 particles/cm^3 respectively (contrast, 15,944 particles/cm^3) for 24-h measurements, compared with 29,338 and 50,067 particles/cm^3, respectively (contrast, 20,729 particles/cm^3) for measurements during 0900 to 1600 hours, which suggests that UFP concentrations may have been overestimated by the model used for the present analysis. However, hourly concentrations measured of 24 h, from 0900 to 1600 hours, and during rush hours (0700–0900 and 1700–1900 hours) were all highly correlated ($r > 0.95$) (Hoek et al., unpublished data).

An additional limitation of the study is that ~15% of the cohort population could not be included due to incomplete residential information. The excluded population was slightly younger than the included (mean age, 42 vs. 50), but otherwise showed similar patterns for important risk factors, including smoking status and education (Table S2).

Conclusion

We report that long-term exposure to UFP was associated with an increased risk of CVD, whereas $PM_{2.5}$ was not associated with these outcomes in our study population. These findings indicate that UFP exposure may result in detrimental health effects in addition to those associated with PM mass exposures. Therefore, the true burden of disease attributable to ambient air pollution may be being underrepresented by current metrics.

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