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Acrylonitrile exposure in the general population and emergency responders following a major train accident in Belgium: a human biomonitoring study

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NVVA, 19/03/2015

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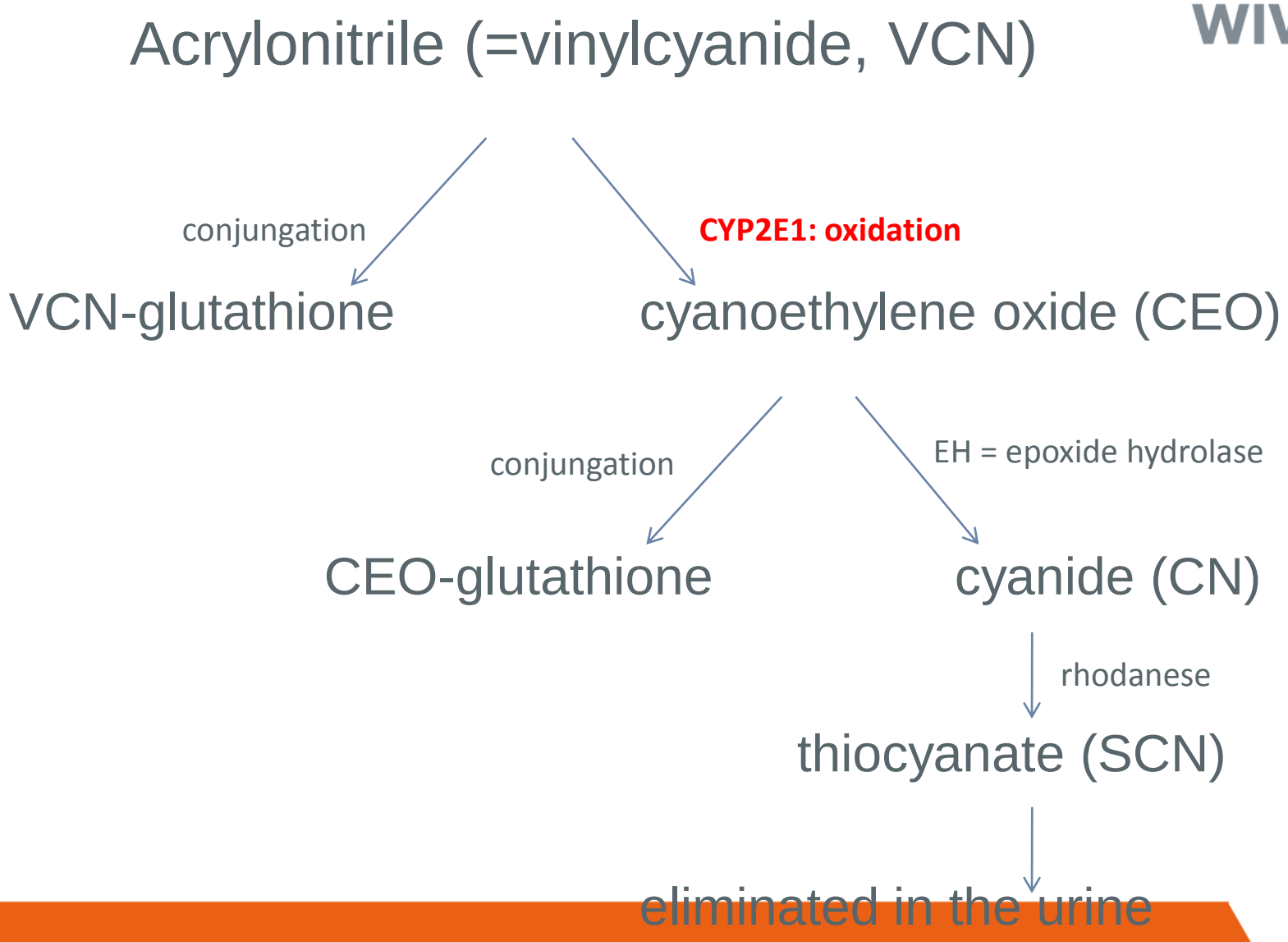
Agenda

- Introduction
- Overview biomonitoring study
  - Data collection
  - Biomonitoring
- Results residents
- Results emergency workers
- Conclusions

Introduction

- May 4 2013 (2h30 AM): rail road accident in Wetteren: derailment of freight cars, explosion, and fire
- Three different substances in freight cars:
  - Butadiene
  - Triethylaluminium
  - Acrylonitrile (ACN)
- Water was used to extinguish the fire

Acrylonitrile metabolism



Although acrylonitrile is heavier than air it can ascend in the sewer system of houses that have either no or a failing isolation from the main sewer system.

RWZI

Introduction

- One resident was found deceased in his house with his dead dog
- One resident experienced cardiac arrest, but was successfully resuscitated
- One resident developed deep coma
- Around 200 residents presented at the emergency services of the surrounding hospitals
- More than 2000 residents were evacuated
- More than 2000 emergency workers were involved in the on-site management

"TOESTAND ECHT ALARMEREND"

De Standaard

VTM NIEUWS

Expert waarschuwt na treinramp: Verhoogde kans op longkanker'

Nieuwsblad.be

"Bloed laten invriezen als bewijs voor later"

08/05/13, 07u59

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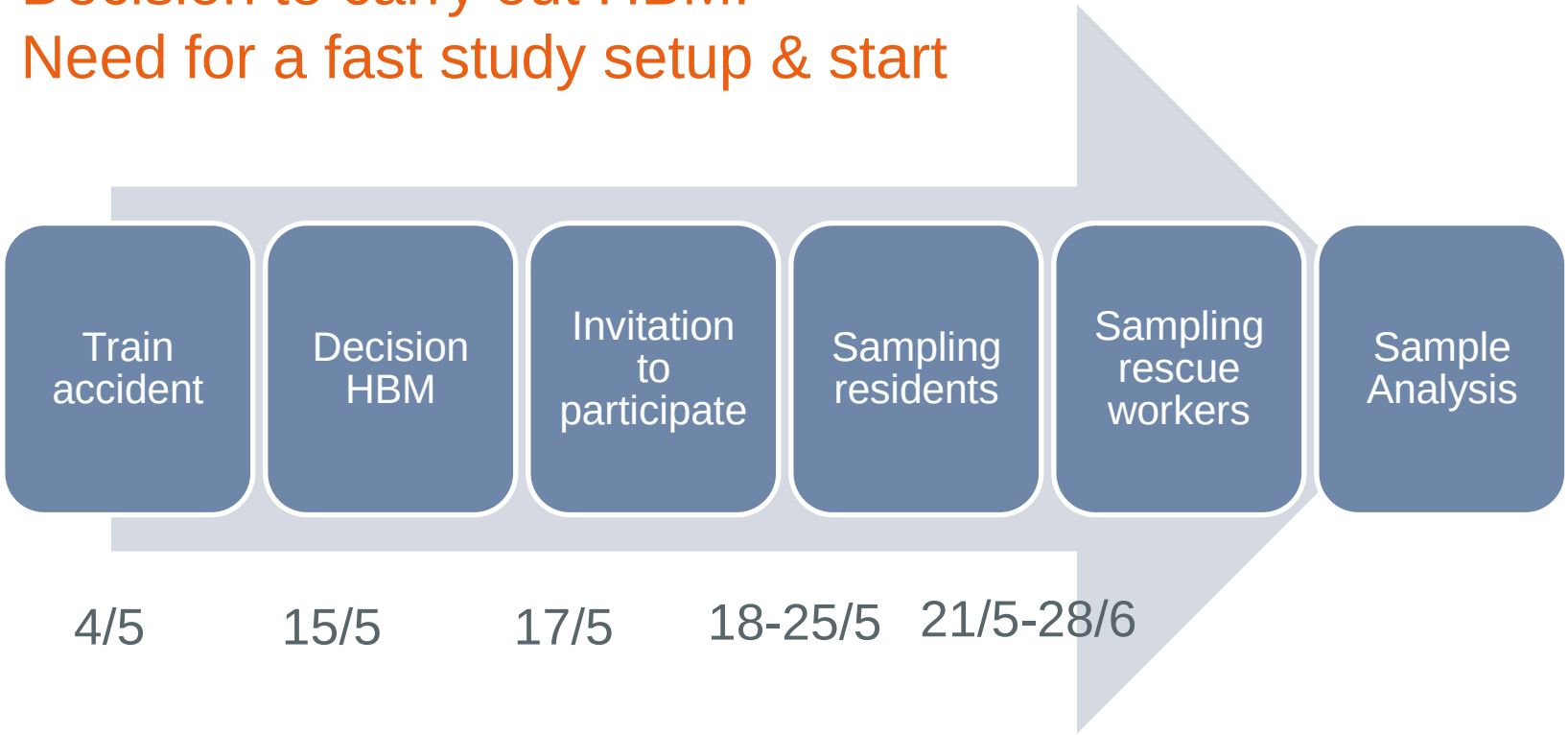
Introduction

Human biomonitoring (HBM)

- Pressure from the media and public opinion “to do something”
- Pro
  - Every individual has the right to know whether he or she has been exposed
  - “Proof of exposure can be used in judicial/insurance matters when developing e.g. cancer”
  - Interesting from a scientific viewpoint
  - Information can be used in management of future incidents
- Con
  - Psychological impact
  - High cost
  - Exposure does not mean risk

Introduction

Decision to carry out HBM:
Need for a fast study setup & start



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Objective

To assess the human exposure to acrylonitrile (ACN) in the populations with highest suspected exposure, i.e. the residents of Wetteren and the persons that assisted professionally in the accident.

Data collection

Sampling: from May 18 till May 25 2013 for residents and May 21 till June 28 2013 for emergency responders

Coordination: FPS Health, Food Chain Safety and Environment + collaboration with the Province, the commune of Wetteren, the local general practitioners and occupational health services

Ethics: study protocol approved by UZ Ghent

Informed consent signed by all participants

Data collection

- **Blood:** *N*-2-cyanoethylvaline (CEV)

  → Biomarker for exposure to ACN

- **Urine:** cotinine

  → Biomarker for tobacco smoke exposure

- **Questionnaire:**

  Demographic variables, smoking status, sampling day and hour, detailed info about presence near the accident (time-space), symptoms.

Data collection

N-2-cyanoethylvaline (CEV)

- CEV is an adduct resulting from the binding of a metabolite of acrylonitrile to haemoglobin
- CEV is not toxic
- Highly sensitive and specific for exposure to acrylonitrile
- CEV level declines linearly to the background value during the lifespan of the circulating erythrocytes (126 days)
- Cigarette smoke contains acrylonitrile

Data collection

Principle: CEV adducts decrease linearly with time by 0,8% per day

Formula:

Extrapolated CEV = measured CEV / (1 – t x 0,008)

Where ‘t’ = nb of days between accident and blood sampling

Ref: Bader *et al*., Toxicology Letter, 2006

Biomonitoring

CEV analyses

- Pretreatment at WIV-ISP → lysate of erythrocytes
- Because of need of substantial analyzing capacity
  → 3 German labs (G-Equas – additional interlaboratory comparison: comparable results among labs)
- Adduct dosimetry: modified Edman degradation
  (Von Sittert *et al*, 1986; Tornqvist *et al*, 1997)

Biomonitoring

Cotinine analyses

- online-SPE-UPLC-MS/-MS (De Cremer *et al*, 2013)

→ Definition of smoking status according to urinary cotinine levels and self-reported smoking status (questionnaire)

Urinary cotinine (µg/L) + questionnaire	
> 100 µg/L	Smoker
25 – 100 µg/L	
Self-reported current smokers	Smoker
Self-reported occasional smokers	Smoker
Self-reported ex-smokers	Non-Smoker
Self-reported non-smokers	Non-Smoker
< 25 µg/L	Non-Smoker

Biomonitoring

Reference values CEV:

- Non-smokers: 10 pmol/g globin
- Smokers: 200 pmol/g globin

- Reference value is the 95^{e} percentile observed in the general population (not accidentally exposed to ACN).
- It correspond to the « upper limit » normally observed.
- Clearly more uncertain in smokers because CEV adduct levels may be very influenced by the tobacco consumption.

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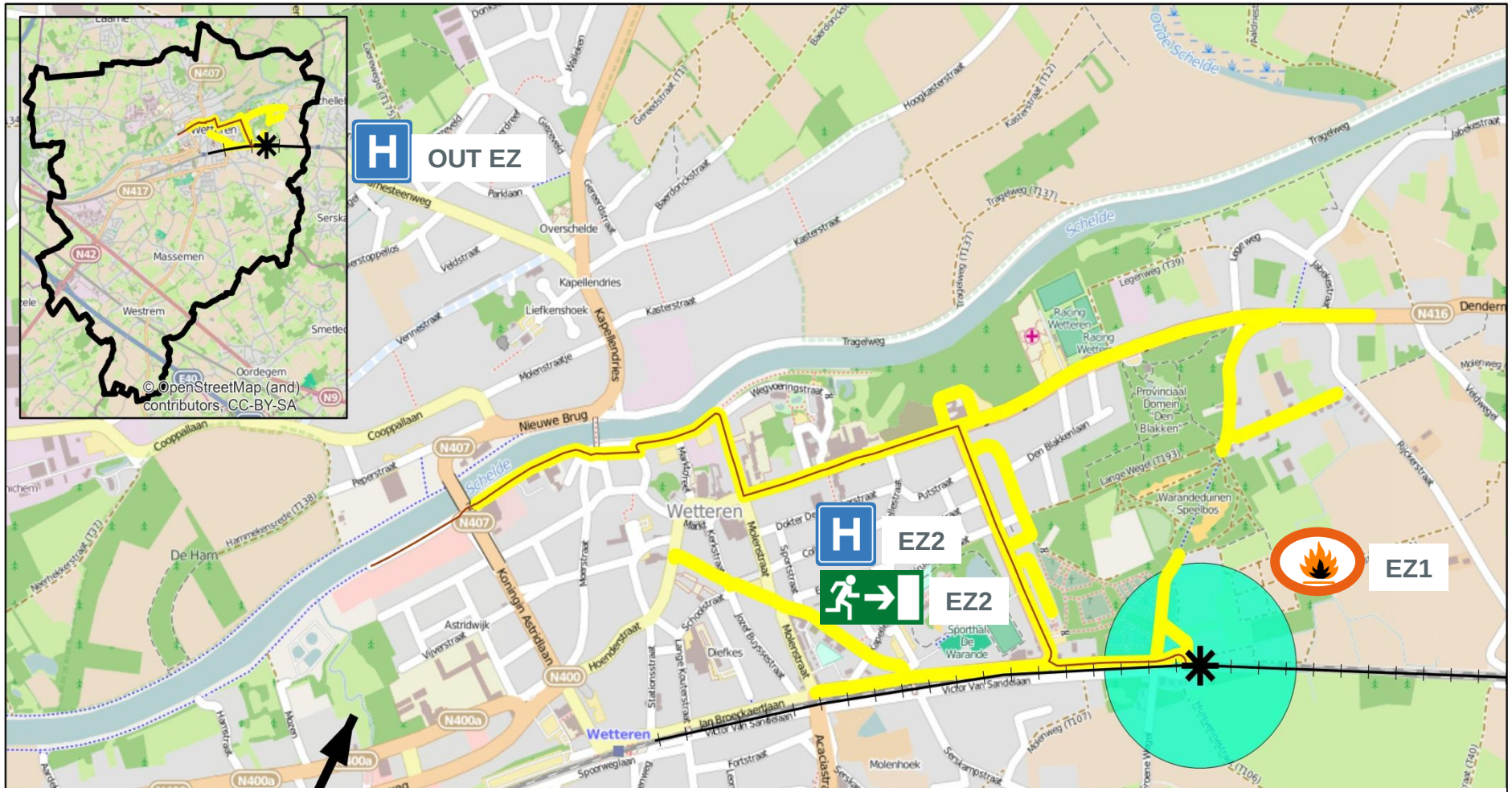


Train accident

Railroad

Sewerage system

Prevailing wind directions at the moment of and in the days following the accident

Zone 1 (EZ1): 250m perimeter of the evacuation zone that was evacuated at night in the hours following the accident

Zone 2 (EZ2): streets parallel with the sewage system and downwind of the train accident that were evacuated later, i.e. in the days following the accident

Zone of 'Controls': the commune of Wetteren, EZ1 and EZ2 excluded

Results residents

The **eligible population** consisted of:

EZ1 All the residents living within EZ1

EZ2 All the residents living in EZ2 who presented at the emergency services

EZ2 10% sample of the residents living in EZ2 who were evacuated, but dit not present at the emergency services

OUT EZ All the residents of Wetteren living outside the EZ who presented at the emergency services

Children below the age of 10 were not included in the study.

Results residents

	 EZ1	 EZ2	 EZ2	 OUT EZ	Total
Eligible (n)	40	99	219	116	474
Participants (n, %)	**26** (65.0)	**47** (47.5)	**124** (56.6)	**45** (38.8)	**242** (51.1)
Age (years) Median (IQR)	48.5 (39.3-68.5)	47.0 (34.0-57.3)	48.0 (33.3-61.0)	34.0 (24.5-46.5)	45.0 (32.0-58.5)
Men n (%)	13 (50)	19 (40.4)	51 (41.1)	17 (37.8)	100 (41.3)
Non-smokers (%)	20 (76.9)	33 (70.2)	89 (71.8)	26 (57.8)	168 (69.4)

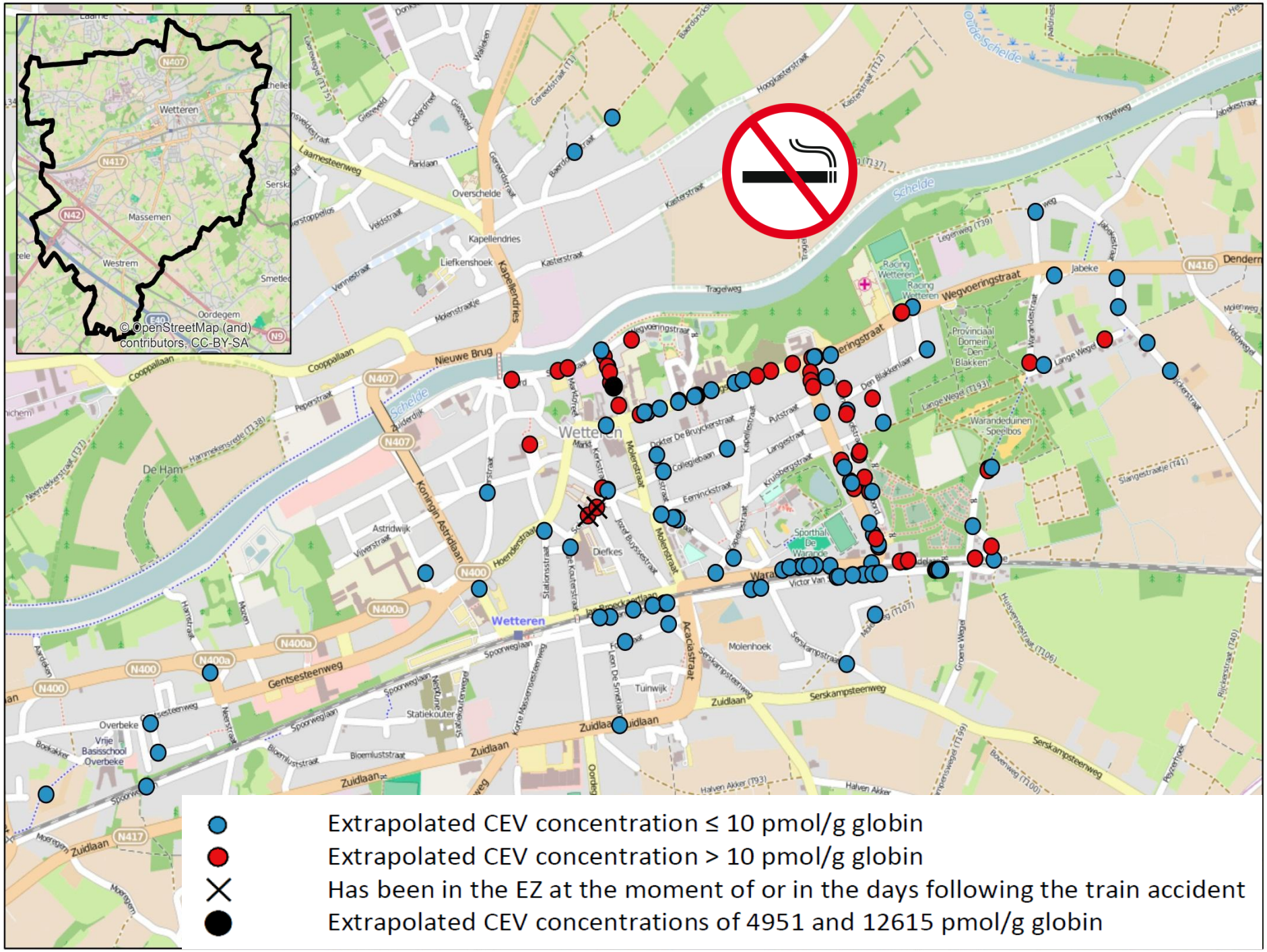
CEV(*) in the different EZ zones

Non-smokers	EZ1 (n=20)	EZ2 (n=33)	EZ2 (n=89)	OUT EZ (n=26)
Mean (SD)	13.7 (15.4)	662.8 (2325.0)	80.9 (317.0)	4.3 (3.3)
Median (IQR)	9.9 (4.0-14.4)	8.0 (5.7-67.6)	6.8 (3.4-15.8)	3.0 (2.3-5.7)
P95	35.9	2760.6	339.5	8.2
Maximum	64.8	12614.8	2128,5	16.2
>ref value n(%)Ŧ	10 (50.0)^	13 (39.3)$	30 (33.7)$	1 (4.2)*

Ŧ10 pmol/g globin

* P value = 0.003; ^P value = 0.310 ; $ P value = 0,711

CEV concentrations extrapolated at the moment of the train accident (pmol/g globin)


© OpenStreetMap (and) contributors, CC-BY-SA
Wetteren
Massemen
Westrem
Oordegem
Smetlede
Laarne
N407
N417
N42
E40
N9
Extrapolated CEV concentration ≤ 10 pmol/g globin
Extrapolated CEV concentration > 10 pmol/g globin
Has been in the EZ at the moment of or in the days following the train accident
Extrapolated CEV concentrations of 4951 and 12615 pmol/g globin

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Results emergency workers

- Eligible population:

  All the **emergency responders** involved in the on-site management of the train accident from May 4 to May 13 (n=1054)

- Final study population for the analysis: n = 841

= participants with blood CEV measures, urinary cotinine measures, and complete information from questionnaire and function.

Results emergency workers

→ 5 categories of functions:

1. **fire-fighters**
2. **police**
3. **civil protection**
4. **army**
5. **others** (including medical staff, journalists, wastewater management team, and soil remediation team)

Results emergency workers

Characteristics of the study population (n = 841)

	fire-fighters	police	civil protection	army	others	total
N (%)	450 (54%)	286 (34%)	35 (4.2%)	22 (2.6%)	48 (5.7%)	841
Men (n, %)	439 (97.6%)	224 (78.3%)	35 (100%)	21 (95.5%)	34 (70.8%)	753 (89.5%)
Age (median, IQR)	40.0 (33-46)	35.0 (29-44)	46.5 (41-49)	35.5 (31-49)	39.0 (31-46)	38.0 (32-46)
Smokers (n, %)	114 (25.3%)	67 (23.4%)	8 (22.9%)	5 (22.7%)	12 (25.0%)	206 (24.5%)

Results emergency workers

Extrapolated CEV concentrations (pmol/g globin) in the non-smokers, by function (n = 635).

	fire-fighters	police	civil protection	army	others	total
N	336	219	27	17	36	635
Median (IQR)	4.4 (2.6-17)	2.9 (2.6-5.1)	15 (6.1-47)	2.6 (1.3-5.1)	5.1 (2.9-10)	3.2 (2.6-10)
95th percentile	91	26	110	11	217	73
Maximum	452	117	147	11	379	452
N (%) > ref value*	106 (31.5%)	29 (13.2%)	16 (59.3%)	1 (5.9%)	11 (30.6%)	163 (25,7%)

* 10 pmol/g globin

Results emergency workers

Group «others»: affiliation of the highest CEV values (non smokers)

CEV_extrap.	AFFILIATION
379,0	Medical staff
216,9	Aquafin + Ovam
127,6	Aquafin + Ovam
57,5	Aquafin
42,3	Aquafin + Ovam
36,2	ECOREM (veldwerkbegeleider bodemsanering)
33,5	Aquafin + Ovam
30,6	Journalist
15,5	Aquafin + Ovam
10,8	Aquafin + Ovam

→ 7 of the 10 highest values for this group are from Aquafin/Ovam

Conclusions

In the non-smoking residents, some clear patterns with regard to ACN exposure following the train accident were seen in function of the subgroups.

The non-smoking emergency responders had significantly lower concentrations as compared to the residents. Fire fighters and civil protection staff had higher CEV concentrations.

In smokers, no such patterns were observed. CEV adduct levels may be very influenced by the tobacco consumption.

Acknowledgments

This study has been financed by the FPS Health, Food Chain Safety and Environment, following an advice of the Belgian Minister of Social Affairs and Public Health. The authors thank the inhabitants of Wetteren for their participation in the study and the local practitioners for their assistance in the sampling and their close involvement throughout the whole study. The authors thank Geert Gijs, crisis coordinator of the FPS Health, Food Chain Safety and Environment, and his team for the logistical organisation of the study. The authors are grateful to Wesley Van Dessel and Jan Eyckmans, respective heads of the communication services of the WIV-ISP and of the FSP Health, Food Chain Safety and Environment, and their team members, for the continuous support in the communication of the study and its results. The authors also want to thank Stéphanie Fraselle and her colleagues (WIV-ISP) for the preparation of the blood samples before sending them to the German labs. Finally, the authors thank Sabine Janssens and Tadek Krzywania and his team (WIV-ISP) for the enormous efforts with regard to data input, data processing and administrative support.

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Thank you for your attention!