European Journal of Public Health, 2025, ckaf014

https://doi.org/10.1093/eurpub/ckaf014

Long-term health effects of a third-generation waste-to-energy plant: the experience of Turin (Italy)

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Abstract

The long-term study on adverse health effects of the third-generation waste-to-energy (WTE) plant located in Turin, Italy, is part of a broader health surveillance system. We considered 369 236 subjects living in areas with different levels of emission fallout, as well as a control group, from 1 January 2014, until the end of the follow-up period. Hospital admissions for cardiac diseases (ICD-IX: 390–429), ischaemic heart diseases (ICD IX: 410–414), chronic heart failure (ICD IX: 428.0, 428.2, 428.9), cerebrovascular diseases (ICD IX: 430–438), acute respiratory diseases (ICD IX: 460–466, 480–487), and COPD (ICD IX: 490–492, 494, 496) were evaluated for the population considered. Cox models were used, considering individual characteristics and overall environmental exposure. We also considered all births ($n = 8296$) of women residing in the area at the time of delivery during the study period. Log-binomial models were run separately for each outcome (sex ratio, multiple births, preterm births, on term low birthweight and small for gestational age births), adjusting for exposure to other pollution sources and maternal characteristics. Miscarriages were evaluated using hospital admissions registries. No relationship was found for the outcomes considered in the wider area, neither with hospital admissions nor with adverse reproductive outcomes. There is an association with chronic heart failure and ischaemic heart diseases in the maximum exposure area, but the small number of events suggests caution in interpreting this result. This study confirm results of other health surveillance lines, showing no evident harmful effects of the WTE plant.

Introduction

The management of non-recyclable urban waste is a matter of concern for public administrations. An alternative to landfills is new-generation waste-to-energy (WTE) plants, which convert municipal solid waste, a source of pollution, into renewable energy sources such as district heating. However, the construction of a new WTE plant raises concerns for nearby residents due to potential harmful effects, especially in densely populated areas [1]. Built between 2010 and 2013 in Gerbido (Turin, Italy), the Turin WTE plant transforms combustion heat into electrical and thermal energy. Between 2013 and 2018, 2.4 million tonnes of wastes were treated, producing over 399 000 MW/h of electricity in 2018. Emissions are continuously monitored by the Environmental Protection Agency of Piedmont Region. Concerns from the population prompted local health authorities and the scientific community to set up a health surveillance system for residents, workers, and farmers in the area with expected maximum fallout.

The Waste Incineration Directive 2000/76/EC and after it the Industrial Emissions Directive 2010/75/EU, later transposed in Italy by the Legislative Decree 46/2014 (European Commission, 2000; European Commission, 2010) aim to achieve high levels of environment and health protection. Few studies have been published on last-generation plants, with methodological heterogeneity [2].

The rationale of the SPoTT program (www.dors.it/spott) has been previously described [3]. It includes human biomonitoring on a cohort of residents [4–7] and WTE workers [8], along with an epidemiological study on short-term effects [9]. After a partial stop during pandemic years, this surveillance program has been renewed until 2026, including analyses on mercury deposition, post-operam fallout maps, and studies on eggs from chickens and hay in four farms in the area.

All these activities aim to monitor and identify adverse environmental and health effects, providing indications for prevention. Part of this surveillance system aims to monitor possible medium- and long-term effects on cardiac and respiratory diseases and adverse reproductive effects outcomes for people living near the plant.

This paper aims to provide an initial indication of possible medium- and long-term effects in terms of hospital admissions for cardio-respiratory diseases and adverse pregnancy outcomes.

Methods

Study design

The population under investigation includes residents living in Turin and four other small municipalities in the outskirts near the WTE plant. The area selection to define exposure levels was based on forecasting fallout of heavy metals (see Supplementary Fig. S1). We consider two levels of exposure:

- EXP group, which has a maximum potential fallout higher than 0.007 μg/m^2/year of heavy metals (dry deposition) and is the same used in short-term effects analyses [9].
- EXP2 group, which has a maximum potential fallout higher than 0.014 μg/m^2/year of heavy metals (dry deposition) and is the same used in biomonitoring analyses [3].

According to this definition, the EXP2 area is included in the wider EXP area. A 300 m buffer zone was established to better separate the unexposed group (NOEXP) from the exposed one (EXP). Only residents in the southern part of Turin were considered as NOEXP to ensure that the socio-economic characteristics and overall environmental pollution levels of the study districts were as similar as possible to those of the EXP group. The fallout maps used to define the exposed population have been previously described [3].

Analyses for the EXP2 area were conducted when the number of events ensured the robustness of the statistical analyses.

The cohort was enrolled from municipal archive registries and linked with hospital admissions (SDO) and certificate of delivery care (CEDAP). Residents aged more than 35 years in the area under investigation at 1 January 2014 were included in the hospital admissions analyses only if they maintained residence in the starting exposure group for at least one year. In case of emigration outside the area or address changes to another exposure group, subjects were considered lost to follow-up from the date the event occurred.

Data sources and outcomes under study

SDO and CEDAP have been used to identify diseases and adverse birth outcomes in the population near the plant. Due to the SARS-COV2 outbreak, data from 2020 and 2021 have issues related to changes in healthcare system access during the pandemic. Problem with coding for respiratory diseases at the beginning of the outbreak, lost to follow-up in screening programs, and differential emergency room access affected the healthcare system in Piedmont Region. Given these difficulties, follow-up was restricted to 2019 to provide an initial indication of potential adverse health effects, avoiding possible distortions in the subsequent years. Cancers were not investigated since the latency period between exposure and symptom onset may require a longer follow-up period.

According to the literature [2], we selected the following main group of causes: Diseases of the circulatory system (ICD-9 code 390–459) and diseases of the respiratory system (ICD-9 code 460–519). Additionally, we investigated the following specific causes: cardiac diseases (ICD-IX code 390–429), ischaemic heart diseases (ICD IX code 410–414), chronic heart failure (ICD IX codes 428.0, 428.2, 428.9 searched in all field of diagnoses), cerebrovascular diseases (ICD IX 430–438 in the main diagnosis), acute respiratory diseases (ICD IX: 460–466, 480–487 in the main diagnosis), and COPD excluded asthma (ICD IX: 490–492, 494, 496 in the main diagnosis).

Following the Moniter project on first- and second-generation plants in the Emilia Romagna Region of Northern Italy [10], the adverse reproductive outcomes analysed are: multiple births, sex ratio, preterm birth (born before then 37 weeks), on term low birth weight (less than 2500 g), and small for gestational age (newborn below 10th percentile based on the distribution of new-borns to Italian mothers, by infant sex, gestational age and parity [11]). We included in the cohort women who remained in the same exposure group throughout their pregnancy. Since miscarriage information is derived from hospital admissions, with no record of the weeks of pregnancy at which the event occurred, we applied the conservative choice to include women with at least 40 weeks before the event at the same exposure level.

The follow-up covered the period from 1 January 2014 to 31 December 2019 for hospital admissions, and from 1 January 2017 to 31 December 2019 for reproductive outcomes. This shorter period is due to the inability to perform a record linkage of newborns between CEDAP and SDO with municipal archive registries, thus lacking accurate information on residential addresses. Miscarriage outcomes were derived from SDO and analysed throughout the entire follow-up period.

The area is highly polluted due to industrial and traffic emissions, so there was the need to include environmental variables to better characterize the area and distinguish the health effects of WTE from other pollution sources. Initially, we considered PM2.5 or NO_2 levels from chemical transport models on a 1 km × 1 km grid. However, the overall variability of these pollutants in the area is low, making local variations difficult to identify. For PM2.5, 90% of the EXP group lives in a range between 22.3 and 34.7 μg/m^3 (median 32.8 μg/m^3), while 90% of the NOEXP group is exposed to a range between 21.4 and 32.8 μg/m^3 (median 29.3 μg/m^3). As an alternative, we used more detailed information on emission sources, considering traffic and emissions from other plants. Traffic load data were introduced only in sensitivity analyses (see Supplementary Table S1) due to inadequate coverage, particularly in the neighbourhoods of Turin. To control for overall environmental pollution, we considered data from 20 sources in the area which emitted PM2.5 and/or NOx (excluding the WTE plant).

Statistical analyses

In hospital admissions analyses, the effect of long-term exposure to WTE is modelled using Cox proportional hazard model for each outcome. We estimate hazard ratios (HRs) adjusted for individual and census variables. To distinguish the effects of WTE emissions from overall pollution in the area, each residential address has been classified into two categories: 1 if within 1 km from at least one plant, and 0 otherwise. In sensitivity analyses, traffic load within a 300 m buffer around the residential address was considered. Each road segment available in the dataset was classified into three categories based on daily vehicles number: low (<1000), medium (1000–5000), and high (>5000).

Another variable included is 2011 deprivation index for each census tract derived from Italian Institute of Statistics (ISTAT), categorized into quintiles [12, 13]. The temporal discrepancy between the deprivation index calculation and the start of the follow-up is the main reason for missing data, due to the inclusion of recently built districts in the outskirts.

Regarding individual covariates, gender, and marital status (1 = living with partner, 0 = not living with partner) were evaluated for inclusion in the models. Not all municipal registries had the same accuracy in recording professional activity and educational level, so these were excluded from the models.

The proportional hazard assumption was tested for all fixed predictors, and stratified Cox models were applied for those that did not meet the assumption. Hazard ratios are calculated with 90% confidence interval for each outcome.

For adverse health effect on pregnancy outcomes, log-binomial models have been used and results are reported as prevalence ratio [14], except for miscarriage, analysed with a binomial model. Thanks to the accuracy of information included in CEDAP, we added two variables in the model: maternal educational level (≤8 years, 9–13 years, ≥14 years) and professional status (housewife, employed, unemployed, not declared). Miscarriage frequency is calculated using Simplified True Abortion Risk (STAR)

$$STAR = SAB/(SAB + LB + SB + rIAB) * 100$$

where SAB, spontaneous abortions; LB, live births; SB, stillbirths; IAB, legally induced abortions; and *r*, proportion of induced abortions that should be added because at risk of becoming miscarriages, ranging from 0 to 1, taken equal to 1/2 in analogy with Moniter project [15].

Analyses were conducted using SAS Version 9.4. [16] and R 4.0.3 [17].

Results

A total of 369 236 subjects have been included in the study, with 248 757 (67.3% of the total) in the NOEXP area and 120 479 (32.6%) in the EXP area, with 8660 (7.2% of the exposed) living in the EXP2 area. Of the NOEXP sample, 82.7% lived in the municipality of Turin. Descriptive statistics of the population are included in Table 1. The distribution of the population with respect to covariates included in the model does not show statistically significant differences between the two groups, except for living alone (*P*

Table 1. Characterization of the cohort studied for hospital admission outcomes by different level of exposure (EXP: maximum fallout > 0.007 μg/m^2/year, EXP2: maximum fallout > 0.014 μg/m^2/year, NOEXP: not exposed group)[a]

	NOEXP		EXP		EXP2		Total	
	No.	%	No.	%	No.	%	No.	%
Overall	248 757	67.4	120 479	32.6	6508	1.8	369 236	100
Sex (males)	112 560	45.2	55 318	45.9	3047	46.8	167 878	45.5
Age class								
35–49	83 617	33.6	38 707	32.1	2098	32.2	122 324	33.1
50–64	73 618	29.8	35 111	29.1	2078	31.9	108 729	29.4
65–74	45 519	18.3	23 593	19.6	1281	19.7	69 112	18.7
75–84	33 940	13.6	18 062	15.0	818	12.6	52 002	14.1
85+	12 063	4.8	5006	4.2	233	3.6	17 069	4.6
Living near industrial plant (yes)	26 333	10.6	23 189	19.3	2619	40.2	49 522	13.4
Living alone (yes)	45 256	18.2	16 029	13.3	1035	15.9	61 285	16.6
Deprivation index								
Very high	55 801	22.4	19 660	16.3	1162	17.9	75 461	20.4
High	47 262	19.0	22 463	18.6	384	5.9	69 725	18.9
Medium	46 666	18.8	25 902	21.5	439	6.8	72 568	19.7
Low	33 740	13.6	17 722	14.7	1277	19.6	51 462	13.9
Very low	31 904	12.8	20 940	17.4	569	8.7	52 844	14.3
Missing	33 384	13.4	13 792	11.4	2677	41.1	47 176	12.8

a: Percentages in the first row are calculated on the total, percentages in other rows are calculated with respect to the specific exposure group.

values < 0.0001) and deprivation index (P values < 0.0001). The percentage of people living alone is higher in NOEXP (18.2% versus 13.3%). It is worth noting that the percentage of people living near an industrial plant (excluding WTE) is higher in EXP2 (40.2%) than in EXP (19.3%) or in NOEXP (10.6%), highlighting other emission sources near the WTE. As a sensitivity analysis, we excluded people living near other industrial plants.

The deprivation index was excluded from statistical analyses on EXP2 due to the large number of missing values (41.1%) associated with recent buildings or with the definition of new census tracts. Living with partner was also excluded since this variable was not significant in the analyses performed.

Table 2 shows the distribution of hospital admissions divided by exposure zone. The P values reported is based on chi-square test to test differences in prevalence of diseases between EXP and NOEXP groups. The percentage of events reflects the distribution of the population among the different groups. For cardiac diseases and ischaemic heart diseases the proportion of events is higher in the EXP group compared to the percentage of population (32.6%), whereas for COPD the proportion is higher in the NOEXP group.

Hazard ratios (HRs) are reported considering NOEXP as reference. No significant HR increases (at 90% levels) associated with WTE emissions were found in the EXP group. For the EXP2 group, HRs for chronic heart failure, ischaemic heart diseases, and respiratory diseases are statistically significant, indicating a 30%, 17%, and 11% higher risk, respectively, for those who live close to WTE plant of being hospitalized for these diseases compared to NOEXP. However, the low number of subjects living in the most exposed area is reflected in the uncertainty in HRs estimates.

Sensitivity analyses were conducted, including an indicator of traffic load within a 200 m neighbourhood around the residential address for each individual. Results including this variable in the model are similar to those obtained from main analyses (see Supplementary Table S1).

Additional sensitivity analyses were performed, removing people living near other industrial plants (see Supplementary Table S2) or adding two intermediate categories of exposure, suggesting a higher risk for ischaemic heart diseases and chronic heart failure hospitalizations in the areas closer to the WTE plant (see Supplementary Table S3).

Considering reproductive outcomes, 8494 babies, corresponding to 8296 births have been recorded in the period 2017–2019 for mothers living in the study area, with 5820 (70.1%) not exposed and 2476 (29.8%) exposed, among which 115 (4.6%) belong to the maximum level of exposure according to fallout maps (Table 3).

The proportion of mothers living near industrial plants and the distribution according to the deprivation index are similar to the overall population. Table 4 shows the distribution of adverse reproductive outcomes divided by exposure zone. Due to the low number of events in the EXP2 group, inferential analyses have been performed only for the sex ratio.

Preterm births show a higher percentage in the EXP and EXP2 groups. To test whether this higher percentage is statistically significant, prevalence ratios have been calculated, including maternal educational level, professional status, deprivation index, and emissions in the model (Table 4).

The prevalence ratio (EXP2 versus NOEXP) for the sex ratio outcome is 1.06(0.89, 1.28). No significant increases emerge from analyses on reproductive outcomes. There is a tendency towards an association in preterm births, but it is not statistically significant. It is worth noting that the tendency in the sex ratio outcome is in the opposite direction compared to other studies on incineration plants.

Discussion

In this paper, we tackled the problem of estimating possible medium-term health effects on the population living near the third-generation Turin WTE plant. It is important to support direct emission control, which can halt combustion if emission exceedances occur, with a health surveillance system that acts as a deeper control. The expansion of WTE technology, which produces energy from combustion for household heating or electrical storage, has led to a large-scale increase in these plants. Therefore, a comprehensive health monitoring system for existing plants is a key public health concern for local authorities. Third-generation plants are a relatively new technology, starting in 2006, so literature on this topic is rather limited.

SPoTT is a comprehensive program on the health effects on the population living near the plant, including biomonitoring of about 400 residents (randomly sampled from exposed and non-exposed groups), and both a short- and a long-term surveillance. This program has been set up to monitor public health over the years, with information derived from healthcare system registries. This could be a limitation, due to the lack of personal information on individuals, which may be useful to better distinguish health effect due to WTE from those derived from other personal exposures or socio-economic deprivation factors. The study published on short-

Table 2. Distribution of subjects by outcome and different level of exposure (EXP: maximum fallout > 0.007 μg/m²/year, EXP2: maximum fallout > 0.014 μg/m²/year, NOEXP: not exposed group)[a]

Outcome	Total	NOEXP	EXP	*P*	EXP2	HR EXP	HR EXP2
Cardiovascular diseases	25 309 (6.85%)	16 802 (6.75%)	8507 (7.06%)	0.004	453 (6.96%)	1.00 (0.97–1.02)	1.02 (0.94–1.10)
Cardiac diseases	16 168 (4.38%)	10 702 (4.3%)	5466 (4.53%)	0.009	298 (4.58%)	1.00 (0.97–1.03)	1.07 (0.97–1.18)
Ischaemic heart diseases	9815 (2.66%)	6495 (2.61%)	3320 (2.76%)	0.007	196 (3.01%)	1.00 (0.97–1.04)	1.17 (1.04–1.32)
Chronic heart failure	5071 (1.37%)	3377 (1.36%)	1694 (1.41%)	0.231	103 (1.58%)	0.99 (0.95 - 1.04)	1.30 (1.10–1.53)
Cerbro-vascular diseases	6911 (1.87%)	4677 (1.88%)	2232 (1.85%)	0.549	109 (1.67%)	0.94 (0.90–0.98)	0.92 (0.79–1.09)
Respiratory diseases	12 999 (3.52%)	8652 (3.48%)	4347 (3.61%)	0.039	244 (3.75%)	0.98 (0.95–1.01)	1.11 (1.00–1.24)
Acute respiratory diseases	4941 (1.34%)	3363 (1.35%)	1578 (1.31%)	0.291	96 (1.48%)	0.92 (0.87–0.96)	1.16 (0.98–1.38)
COPD (asthma excluded)	4647 (1.26%)	3191 (1%)	1454 (1.21%)	0.05	76 (1.17%)	0.88 (0.84–0.93)	0.97 (0.80–1.17)

a: For each outcome, percentages reported are calculated over the population included in each exposure level. *P* values are calculated using chi-square test for EXP group. Hazard ratios (HRs) are reported with 90% confidence intervals. Variables included in the models: age, gender, living near industrial plant, and deprivation index (this last only in EXP analyses). Gender has been included in strata for cardiovascular diseases.

Table 3. Characterization of the cohort considering mother of newborn by different exposure levels (EXP: maximum fallout > 0.007 μg/m²/year, EXP2: maximum fallout > 0.014 μg/m²/year, NOEXP: not exposed group)

	NOEXP		EXP		EXP2		Total	
	No.	%	No.	%	No.	%	No.	%
Total	5962	70.2	2532	29.8	112	1.3	8494	100
Age class								
15–20	55	0.9	23	0.9	0	0.0	78	0.9
21–34	3369	56.5	1528	60.3	73	65.2	4897	57.7
35–40	2160	36.2	844	33.3	34	30.4	3004	35.4
41–49	378	6.3	137	5.4	5	4.5	515	6.1
Educational level								
Low (≤8 years)	1469	24.6	650	25.7	18	16.1	2119	24.9
Medium (9–13 years)	2076	34.8	1198	47.3	63	56.3	3274	38.5
High (≥14 years)	2417	40.5	684	27.0	31	27.7	3101	36.5
Occupation								
Housewife	615	10.3	256	10.1	11	9.8	871	10.3
Employed	3806	63.8	1622	64.1	75	67.0	5428	63.9
Unemployed	732	12.3	374	14.8	16	14.3	1106	13.0
Not declared	809	13.6	280	11.1	10	8.9	1089	12.8
Living near industrial plant (yes)	646	11.1	467	18.9	40	35.7	1113	13.4
Deprivation index								
Very high	1173	19.7	360	14.2	31	27.7	1533	18.0
High	1178	19.8	447	17.7	3	2.7	1625	19.1
Medium	1176	19.6	527	20.8	12	10.7	1703	20.1
Low	806	13.5	423	16.7	14	12.5	1229	14.5
Very low	822	13.8	464	18.3	10	8.9	1286	15.1
Missing	807	13.5	311	12.4	42	37.5	1118	13.2

term effects investigated possible immediate relationships between plant emissions and hospital admissions or emergency room accesses for cardio-respiratory causes. This paper focuses on a wider time span, checking for possible adverse health effects after 6 years of exposure.

In comparison with the literature, we considered hospital admissions for cardiovascular diseases, respiratory causes, and adverse reproductive outcomes. No study on third generation plant has focused on cancers or mortality due to the limited number of follow-up years as in our study. Analyses on the whole cohort on cardio-respiratory diseases suggest the absence of a WTE effect on hospital admissions. Some indications can be seen in the focus on EXP2 group for chronic heart failure, ischaemic heart diseases and respiratory diseases However, the small number of subjects included (6508), together with the limited number of follow-up years, does not permit definitive conclusions. Results are more evident when excluding people living near other industrial sources, but caution is needed as these estimates are calculated on a subgroup of 3889 subjects, so they need to be confirmed after a higher number of follow-up years. These results substantially confirm what has been obtained by the few other studies on third generation plants [2]. Most studies on respiratory and cardiovascular diseases are on second-generation plants, which ensure adequate temporal coverage of follow-up but have older emissions abatement system technologies. The major limit of our study is the definition of the cohort on the basis healthcare registries, thus lacking information on individual data about potential confounding factors such as individual socioeconomic condition, professional exposure, and important personal lifestyle factors such as smoking habits. This could be relevant, and the different distributions in census deprivation index between groups suggest caution in the interpretation of results, which can go in the direction of underestimating possible effects present in this population. Moreover, the large amount of missing data of deprivation index in the most exposed area led to the exclusion of an important socio-economical variable, even if defined at a census level. On the opposite, one major strength of our study is the exposure levels classification based on fallout maps from dispersion models, considering meteorology and chemical reactions, rather than only the distance between residential address and the plant. This approach was also used in the study of Rome [18], where no clear association emerged. However, the comparison is limited since they use PM10 concentrations estimated from dispersion models as

Table 4. Descriptive statistics birth outcomes by different exposure levels (EXP: maximum fallout > 0.007 μg/m^2/year, EXP2: maximum fallout > 0.014 μg/m^2/year, NOEXP: not exposed group)

Outcome	Overall	NOEXP	EXP	EXP2	PR (EXP versus NOEXP)
Miscarriage[a]	2588 (STAR = 16.1%)	1812 (STAR = 16.4%)	776 (STAR = 15.4%)	31 (STAR = 12.2%)	0.89 (0.75–1.06)
Multiple births	99/8296 (1.19%)	71/5820 (1.22%)	28/2476 (1.13%)	≤5	1.00 (0.90–1.10)
Sex ratio (female/total number of newborns)	4156/8494 (48.9%)	2954/5962 (49.5%)	1202/2532 (47.5%)	59/112 (52.7%)	0.96 (0.91–1.01)
Pre-term births	545/8296 (6.6%)	369/5820 (6.3%)	176/2476 (7.1%)	10/115 (8.7%)	1.12 (0.94–1.33)
On term low birthweight	169/8296 (2.0%)	120/5820 (2.1%)	49/2476 (2.0%)	≤5	0.97 (0.69–1.35)
Small for gestational age	718/8296 (8.7%)	491/5820 (8.4%)	227/2476 (9.2%)	7/115 (6.1%)	1.08 (0.93–1.26)

a: In the period 2014–2019. Prevalence ratios for miscarriage are calculated with standard binomial (SDO data 2014–2019), and with log-binomial model for the other outcomes (CEDAP data 2017–2019). Variables included in the model: maternal educational level, professional status, deprivation index and emissions.

indicator of exposure, considering all sources of pollution together (traffic, incinerator, and a landfill in the neighbourhood). In the paper on Emilia-Romagna incinerators [19], a similar study design has been conducted with 14 follow-up years (1990–2003), using healthcare registries too, and defining the exposure area using a modelling approach. Although it was on older plants, no significant association emerged on hospital admissions outcomes, but an excess emerged on mortality. This supports the need to maintain surveillance, with the evaluation of a longer period.

Considering reproductive outcomes, given the short time lag between potential exposure and outcome, we can compare results with other five studies on third-generation plants [2]. We found no relationship with plant emissions, even though the maximum fallout emission area could not be fully evaluated because of the limited number of mothers living there. The major strength of using CEDAP data is the opportunity to better evaluate individual maternal socio-economic conditions, lifestyle, and educational level, avoiding bias that may still remain in hospital admissions analyses. In previous studies, there was evidence of positive findings in some old generation studies on preterm birth [10, 20], whereas the larger UK study found no association [21]. The major weakness of our analyses on reproductive outcomes is the limited years of follow-up (3 years) compared with previous studies. However, no clear association emerged, suggesting the lack of a strong correlation with plant emissions.

A weakness of this study is the reduced number of follow-up years compared to previous studies. However, we had to face the problem of the pandemic years, which inclusion may distort the results obtained. Therefore, we considered it a good compromise to have estimates, even with a limited number of years, to provide an initial indication of the health effects. This may help confirm whether the plant emissions comply with health protection standards. Now it is too early to answer the fundamental issue of the possibility of long-term effects, so all the outcomes included in this paper will be analysed again at the end of the SPoTT program.

This study completes the overview of potential harmful effects of WTE emissions, as part of a wider surveillance health system. It is an intermediate step, complementing biomonitoring results on a small cohort for which no clear effects have emerged until now. Future analyses with longer follow-up period will be needed to evaluate possible associations with cancers and to deeper investigate suggestions of possible increased risks in the area closer to the WTE plant.

Acknowledgements

The authors thank the members of the Scientific Committee, Francesco Forastiere, Fabrizio Minichilli and Roberto Pasetto, as well as the entire SPoTT working group.

Supplementary data

Supplementary data are available at *EURPUB* online.

Conflict of interest: The authors disclose any actual or potential conflict of interest.

Funding

The SPoTT project was financially supported by the Metropolitan Area of Turin (resolution n. 409-18423/2014 of 06/06/2014). The study was approved by the local Ethics Committee.

Data availability

The data underlying this article cannot be shared publicly due to information that could compromise the privacy of research participants. The data will be shared on reasonable request to the corresponding author upon data controller permission, for the purposes of Regulation 2016/679 (the "GDPR").

Key points

- Waste-to-energy plant is a technology that converts municipal solid waste into renewable sources.
- The experience of Turin provides a comprehensive health surveillance system to monitor potential harmful effects.
- Results on medium- to long-term effect after 6 years of functioning show no clear effects in hospital admissions for cardiorespiratory causes among the population living near the plant compared to a control group.
- The same conclusion applies to adverse reproductive outcomes.

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European Journal of Public Health, 2025, 00, 1–6
https://doi.org/10.1093/eurpub/ckaf014
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