

Community perceptions and mental burdens among (former) residents at Europe's largest lignite mine in Western Germany: a cross-sectional study

Von der Medizinischen Fakultät der Rheinisch-Westfälischen Technischen Hochschule Aachen zur Erlangung des akademischen Grades einer Doktorin der Medizin genehmigte  
Dissertation

vorgelegt von

Emma Holtermann

aus

Leverkusen

Berichter: Univ.-Prof. Dr. med. Andrea Kaifie-Pechmann, M.Sc.  
Univ.-Prof. Dr. med. Thomas Kraus

Tag der mündlichen Prüfung: 05.05.2026

Diese Dissertation ist auf den Internetseiten der Universitätsbibliothek online verfügbar.

## **Auflistung der Publikationen**

Holtermann, E., Krüger, T., Kraus, T. *et al.* Community perceptions and mental burdens among (former) residents at Europe's largest lignite mine in Western Germany: a cross-sectional study. *Sci Rep* **15**, 8795 (2025).  
<https://doi.org/10.1038/s41598-025-92834-8>



## OPEN Community perceptions and mental burden among (former) residents at Europe's largest lignite mine in Western Germany: a cross-sectional study

Emma Holtermann<sup>1</sup>✉, Theresa Krüger<sup>1</sup>, Thomas Kraus<sup>1</sup> & Andrea Kaifie<sup>2</sup>

During the many years that coal has been used for energy production, most studies have focused on the global environmental impacts such as climate change or, when addressing health, rather on conditions of open pit coal miners. This study aims to assess the mental health impacts of lignite (brown coal) mining on communities living in proximity to an open pit mine, including resettlers. A questionnaire-based survey was used with items including socioeconomic effects of open pit mining and resettlement, environmental burden, attitudes, as well as scales for depressive and somatic symptoms. Data included  $n=100$  respondents from resettled villages and  $n=235$  participants from pit edge villages nearby Europe's largest open pit mine Hambach in Western Germany. Both groups reported up to twice as high levels of depressive and somatic symptoms compared to the general population. Over 16.0% of all surveyed stated moderate-to-severe depressive symptoms, while 40.0% of respondents from pit edge villages self-reported moderate-to-severe somatic symptom levels (vs. 23.7% in resettled villages). Three out of four respondents from pit edge villages felt often to nearly always affected by dust followed by noise (41.9%). These results suggest that a changing home environment and residential proximity to an open pit mine could affect the mental health, leading to psychological strain. Further studies on the psychosocial impact of environmental change and loss of home are needed.

**Keywords** Resettlement, Open pit mining, Solastalgia, Environmental distress, Mental health

### Fossil fuels at a global to National scale

At the 26th Climate Change Conference in Glasgow on October 31 - November 13, 2021, the participating parties agreed to a “phase-down of unabated coal power” and “phase-out inefficient fossil fuel subsidies”, in order to accelerate their climate protection efforts<sup>1</sup>. 35 countries and four institutions, including Germany, signed a joint commitment on ‘International Public Support for the Clean Energy Transition’, aiming to end new direct public support for the international fossil fuel energy sector by the end of 2022<sup>2</sup>. Lignite is the main source of energy among the fossil fuels used to supply electricity in Germany<sup>3</sup>. In 2020, Germany's coal phase-out law stipulated that no more electricity may be generated by coal after the end of 2038; according to the current coalition agreement even until 2030<sup>4,5</sup>. This Act<sup>4</sup> is an important measure to reduce greenhouse gas emissions, mitigate climate disasters and diminish global heating, while it also ceases local coal extraction-related pollution and the need for further resettlements.

### Research trend of open pit mining

Coal production and combustion lead to various hitherto insufficiently examined problems at a regional scale. When dealing with health, only workers in open pit mines were usually the subject of research<sup>6</sup>. In the USA, for example, surveillance programs (e.g., the Coal Workers' Health Surveillance Program) were implemented to be able to record longer-term effects on the health of open pit miners<sup>7,8</sup>. However, open pit mining does not only affect employees. Residents living near those mines can also be impacted by environmental pollution (e.g., coal

<sup>1</sup>Institute for Occupational, Social, and Environmental Medicine, Medical Faculty, RWTH Aachen University, Pauwelsstrasse 30, 52074 Aachen, Germany. <sup>2</sup>Institute for Occupational, Social, and Environmental Medicine, FAU Erlangen-Nürnberg, Henkestraße 9&11, 91054 Erlangen, Germany. ✉email: emma.holtermann@rwth-aachen.de

dust or noise) and resulting health conditions<sup>9</sup>. So far, those communities are not sufficiently represented in the research landscape<sup>10</sup>. Residential studies mainly focused on noise and its potential (mental) health effects, e.g. relationship between noise exposure and depressive disorders<sup>11–13</sup> or the dimension of noise disturbance<sup>14,15</sup>. In Queensland, research was done on the mental health conditions of residents in coal mining regions, what support services they would find helpful, and how these have to be expanded<sup>16,17</sup>.

Consequences residents are facing can also include extensive ecosystem<sup>18,19</sup> and landscape changes<sup>20</sup>, as well as impairment of local agriculture<sup>21</sup>. Van Haaften described how ‘an environment that starts to erode will induce psychological consequences such as stress and marginalization’<sup>22,23</sup>.

So far only one study in Germany quantitatively assessed potential mental health effects associated with open pit mining focusing on the Garzweiler open pit mine in Western Germany<sup>14</sup>. To generate additional and more comprehensive results, it appears interesting to examine further locations, with a different local and historical context.

Hambach is Europe’s largest open pit mine, covering an area of approximately 4300 hectares<sup>24</sup>. The mine is located in Western Germany (Rhenish region) where in 2021 almost 50% of Germany’s lignite was extracted<sup>25</sup>. Due to the statutory coal phase-out in Germany, the Hambach open pit mine will be closed earlier than planned and no more residents are being resettled nowadays. Current plans envisage the conversion of the open pit mine into a lake while recultivation measures are to be continued<sup>26</sup>. Due to the Hambach open pit mine, large parts of the Hambach Forest had to be cleared. This led to a considerable (international) media attention, due to many demonstrations and longstanding presence of environmental activists in the immediate vicinity of the open pit<sup>27</sup>. As part of the recultivation measures of the spoil heap in the north of the open pit mine Hambach, the Sophienhöhe was created for forestry restoration of the destroyed nature<sup>28</sup>.

### Research objectives and study aim

While it is suggested that environmental degradation has an impact on people’s mental health<sup>29–31</sup>, the role of the familiar environment is particularly important. A changing home environment can also lead to a feeling of distress known under the technical term solastalgia<sup>32</sup>. People feel solastalgia when their sense of place is negatively affected and “manifests in a feeling of dislocation” from their home environment<sup>33</sup>. Reasons can be rather natural (e.g. climate change) but also artificial factors like war, gentrification, or mining<sup>33</sup>. The concept of Solastalgia itself is rooted in a study on a huge mining region in Australia<sup>34</sup>.

So far, some studies addressed the different components of change associated with open pit mining, such as environmental degradation, resettlement and altered social structures.

Our study aims to assess the mental health burden in residents living close to the open pit mine Hambach compared to already resettled people who previously lived close to the Hambach mining area. In addition, study population specific stressors, such as environmental hazards caused by mining for pit edge villagers as well as stressors caused by the resettlement process were determined.

## Materials and methods

### Study population and data gathering

The cross-sectional survey focused on residents, older than 17 years, who lived less than 7 km next to the open pit mine Hambach (pit edge villagers) or who resided there prior to their resettlement (new villages). Both study populations were determined since it is assumed that mining has a different impact on already resettled persons in comparison to residents next to a coal mine.

In April and May 2022, data was collected mainly in three pit edge villages (Buir, Elsdorf, Niederzier-Ellen) and three new villages (Neu-Etzweiler, Morschenich-Neu, Manheim-Neu; meaning newly built settlements for people relocated because of open pit mining), both shown Fig. 1. In general, the new villages were located much further away from the mining site (on average 3.8 km distance compared to 2 km for pit edge villages), assuming a lower mining-caused environmental exposure. Paper-based and online questionnaires were used to reach people of different age, media use and place of residence.

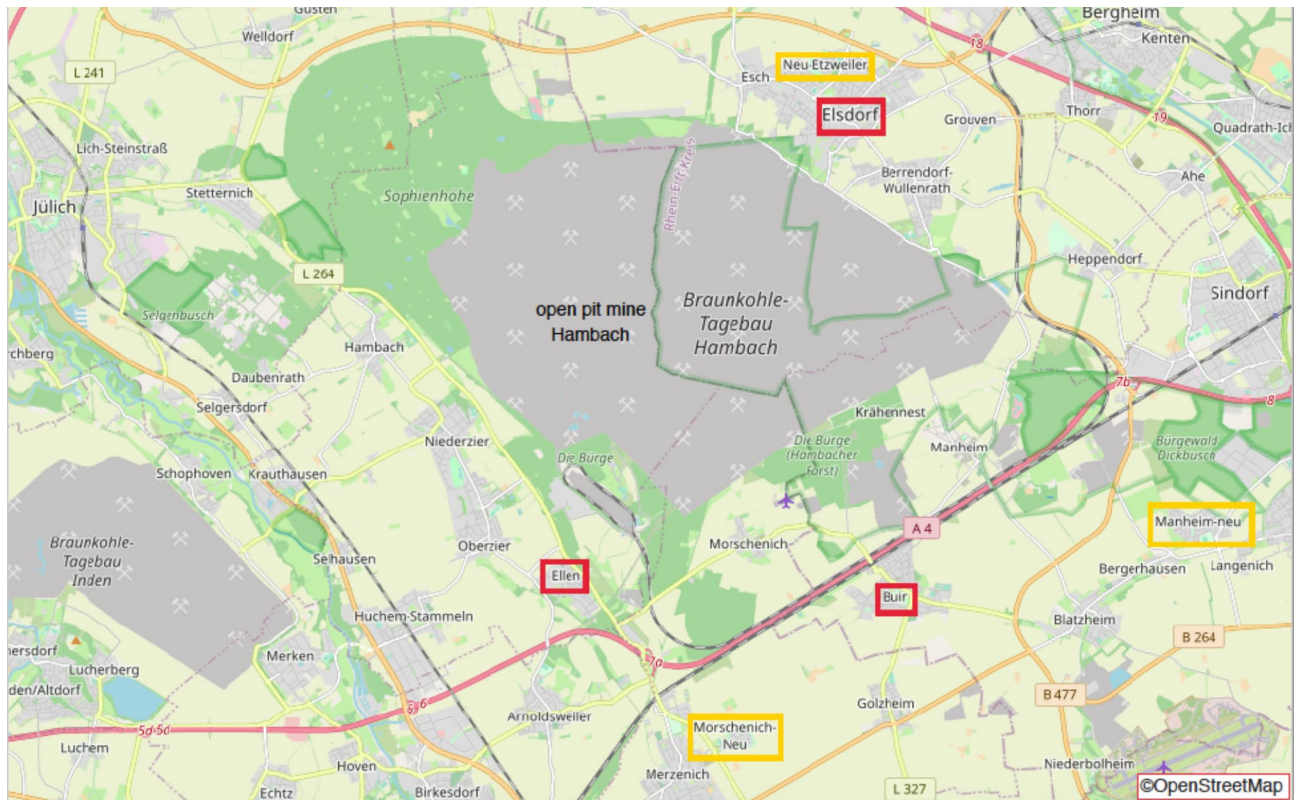
In pit edge villages as well as new villages, 600 questionnaires were distributed by drop off at home, including stamped envelopes for return. A link to the online questionnaire with general information about the study was published via social media (Facebook, Twitter) with the support of local citizens’ initiatives as well as in a local newspaper. Ethical permission for data collection was given from the local Human Research Ethics Committee of the RWTH Aachen University Faculty of Medicine (EK094-22, March 2022).

All participants gave their informed consent to anonymously participate in the study before filling out the questionnaire. It was declared that there were no negative consequences for not filling out the questionnaire. A contact person for psychological support for respondents was named.

The online questionnaire was implemented using SoSci Survey<sup>35</sup> and made available to participants at [www.soscisurvey.de](http://www.soscisurvey.de). It was mandatory for the participants to specify the place of residence. Mainly participants from the Fig. 1 marked places answered the questionnaire. Other villages close to the open pit mine, such as Manheim or Morschenich were already completely abandoned, since the population was resettled.

### Questionnaire and survey scales/ measures

The questionnaire included 74 items for both groups, and an additional 24 items for the people in the new villages, resp. 14 for the people in the pit edge villages. Most questionnaire items were derived from a study by Krueger et al., which was prevalently carried out at the neighboring open pit mine Garzweiler in the Rhenish region<sup>14</sup>. They mainly originate from the Environmental Distress Scale, developed in an Australian open pit mining area<sup>15</sup>. Krueger et al. translated the items into German and included six out of nine items (from the original scale used in the Australian indigenous population) based on local German conditions as well as interviews with



**Fig. 1.** Map of the open pit mine Hambach and surroundings – places are marked (new villages - yellow; pit edge villages – red); OpenStreetMap contributors, edited by the authors.

residents<sup>14,15</sup>. Items were added based on literature research on the local context at the Hambach open pit mine. In addition, the Patient Health Questionnaire-9 & -15<sup>36,37</sup> were used to determine potential mental burden.

First, sociodemographic data, such as age, gender, level of education and for participants from the new villages the period since the resettlement was completed. For all participants, the general effects of open pit mining, such as economic benefits, disagreements over the open pit mine in the community or family, destruction of buildings and nature were assessed. Those effects were rated using a five-point Likert scale from strongly agree to strongly disagree.

Only pit edge villagers were queried for experienced environmental hazards, such as dust, noise, vibration, or nocturnal lighting. Only new villagers were asked for stressors and protective factors during the resettlement process. This included questions concerning physical or psychological exhaustion, financial burden, living conditions, and place attachment to the old village. These questions used a 5-point Likert scale ranging from strongly agree to strongly disagree, as well.

All participants received questions about environmental and community actions including attended community meetings, demonstrations, petitions, or contact to politicians.

Concerning solastalgia, questions from the Australian solastalgia scale<sup>15</sup> were used in accordance to other studies dealing with environmental damage<sup>38,39</sup>. The following questions were asked: “The sense of belonging undermined by mining-induced changes; “I am sad that native nature is being destroyed”; “I am worried that valued aspects of place – clean air, scenery- are being lost”; “I miss peace and quiet once enjoyed in this place”; “I feel sad when looking at mine voids and degraded landscapes”; “The farming lifestyle depending on good land and water is threatened by mining-induced changes”<sup>40</sup>. We used a 5-point Likert scale to measure the levels of solastalgic distress (i.e., 5 = strongly agree to 1 = strongly disagree), with 6 items and a total score ranking from 0 to 30, only evaluated when all items were answered.

Finally, the Patient Health Questionnaire (PHQ-9 & -15) were used in order to assess the mental burden of the participants. The Patient Health Questionnaires-9 & -15 (PHQ-9 & -15) are diagnostic tools for common mental health disorders that determine depressive and somatic symptoms, respectively<sup>36,37</sup>. They are widely used and validated especially in primary health care<sup>41,42</sup>. Symptoms were assessed as followed: 9 items for depressive symptoms during the last two weeks and 13 items for somatic symptoms within the last 4 weeks. PHQ-9 responses were ranked on a 4-point scale (0 = not at all, 1 = several days, 2 = more than half the days, 3 = nearly every day) with a total score from 0 to 27. A 3-point scale was used for the somatic symptoms (0 = not bothered at all, 1 = bothered a little, 2 = bothered a lot), with a total score from 0 to 30. According to the PHQ-D, the score for somatic symptoms is generated from the 13 items of the somatic symptom scale and 2 items of the depressive symptom scale. The two items of the PHQ-9 are scored as 0 (“not at all”), 1 (“on individual days”) and 2 (“on

more than half of the days” or “almost every day”). Cut points of  $\geq 5$ ,  $\geq 10$ , and  $\geq 15$  represent mild, moderate, and severe levels on both scales, respectively<sup>43</sup>.

For dichotomizing, we used a cut-off of  $\geq 10$ , representing moderate-to-severe symptom levels. Not answered items were ranked as a 0, assuming that the symptoms did not occur.

### Statistical analyses

Data were analyzed using SAS Software, Version 9.4. Considering the cross-sectional design, descriptive statistical methods were used. Our main goal was to describe stressors, such as environmental stressors for the pit edge villagers and stressors caused by resettlement in the new village group, and to detect differences between our two study populations, the pit edge villagers, and the new villagers in terms of attitudes towards mining as well as the mental health burden. Therefore, we mainly used descriptive analyses of continuous and categorizable variables. We used in dependence of the variable, Chi-square or Kruskal-Wallis test in order to detect differences, for example concerning the mental burden between our two study populations. Gender-specific alterations were considered. The Spearman correlation coefficient was used for possible associations between the solastalgia-score, PHQ-scores, and period since completed resettlement.  $p < 0.05$  was used as the level of significance.

### Results

A total of  $n = 335$  questionnaires were included in the analyses, with  $n = 235$  (70.1%) people living in pit edge villages and  $n = 100$  (29.9%) people from new (resettled) villages. Questionnaires were excluded from the data analysis when people who lived outside of the 7 km radius next to the open pit mine, did not meet the minimum answer requirements or gave inconclusive answers. Included and excluded participants are shown Fig. 2.

### Sociodemographics

Table 1 gives the respondents' sociodemographic characteristics. The average age of respondents in new villages was 57.1 years, in comparison to 53.6 years in pit edge villages. There were no significant differences for age, gender, marriage/ partnership, university degree, having children or grandchildren living in the village, ownership of residence, or having spent the entire lifetime in the village. 80.8% of the people in the new villages

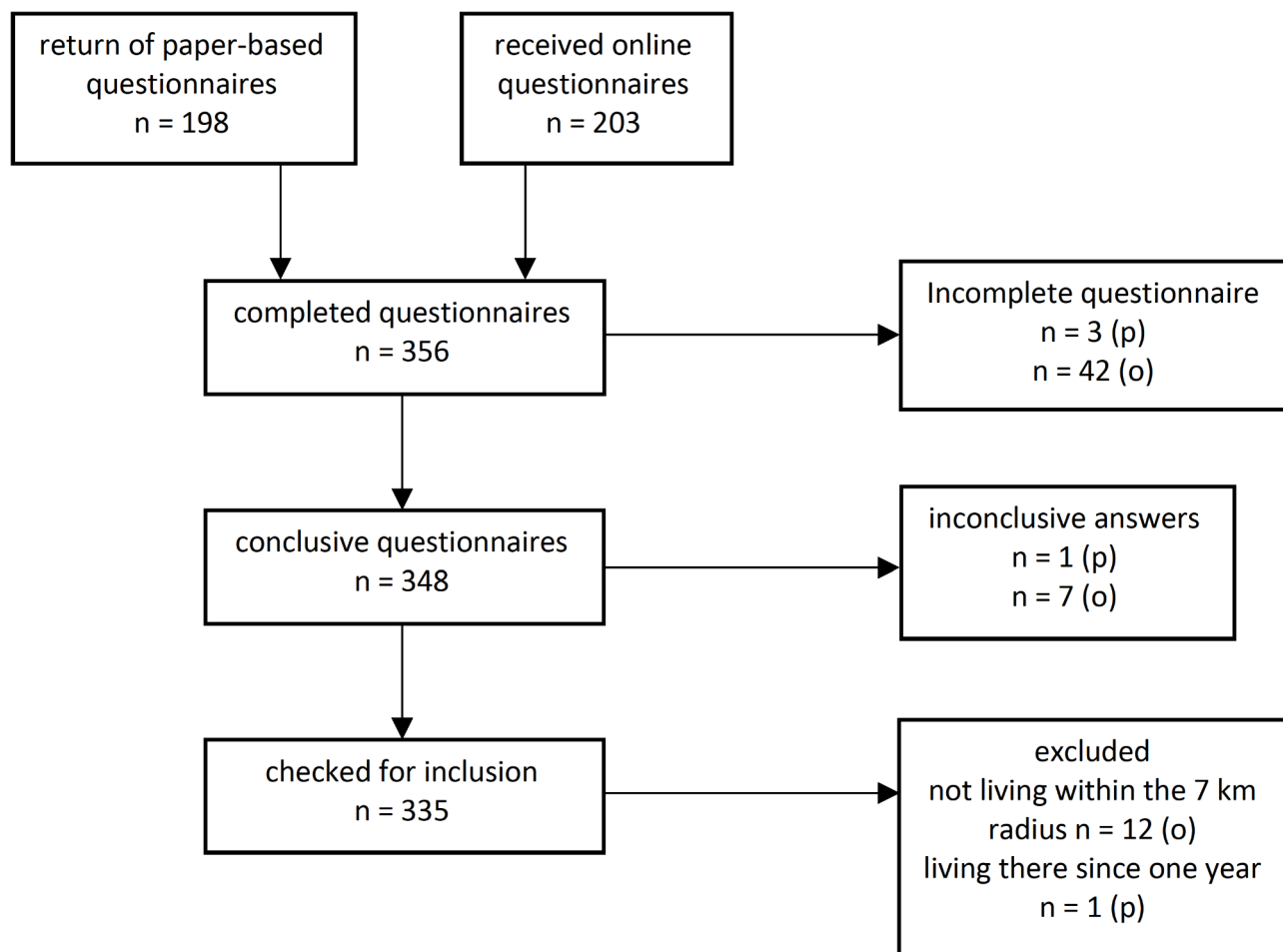


Fig. 2. Flowchart of included and excluded participants.

	New villages <sup>a</sup>	Pit edge villages	<i>p</i> -Value*
	Mean (SD)		
Age	57.1 (17.0) <i>n</i> = 99	53.6 (15.6) <i>n</i> = 232	n.s. <sup>#</sup>
	<i>n</i> (%)		
Female gender	49 (49.0%) <i>n</i> = 100	114 (48.7%) <i>n</i> = 234	n.s.
Marriage or partnership	78 (78.0%) <i>n</i> = 100	182 (77.8%) <i>n</i> = 234	n.s.
University degree	21 (21.2%) <i>n</i> = 99	65 (27.8%) <i>n</i> = 234	n.s.
Children living in the same village <sup>b</sup>	55 (55.0%) <i>n</i> = 100	107 (45.5%) <i>n</i> = 235	n.s.
Grandchildren living in the same village <sup>b</sup>	9 (9.0%) <i>n</i> = 100	15 (6.4%) <i>n</i> = 235	n.s.
Former generations living in the region <sup>c</sup>	80 (80.8%) <i>n</i> = 99	144 (61.8%) <i>n</i> = 233	< 0.001
Living on old family property	54 (54.5%) <i>n</i> = 99	62 (26.6%) <i>n</i> = 233	< 0.001
Ownership of residence	88 (88.9%) <i>n</i> = 99	213 (91.8%) <i>n</i> = 232	n.s.
Entire life spent in the village	43 (43.9%) <i>n</i> = 98	83 (36.2%) <i>n</i> = 229	n.s.

**Table 1.** Sociodemographics. <sup>a</sup> data refer to original location of residence (prior to resettlement), where relevant; <sup>b</sup> includes (grand)children living in the same household; <sup>c</sup> includes parents or older generations; \* chi-square or (<sup>#</sup>) Kruskal-Wallis test; n.s. = not significant; SD = standard deviation.

had former generations living in the region (vs. 61.8% in the pit edge villages;  $p < 0.001$ ). Among respondents in new villages, also more people formerly lived on old family property (54.5% vs. 26.6%;  $p < 0.001$ ).

The mean period since completed resettlement was 111.5 months (SD 100.5; with a range from 4 to 360 months) which is about 9.3 years (not shown in the Table). Excluding respondents who have lived in the village all their lives, the average length of residence of participants in pit edge villages is 27.7 years (not shown in the Table).

### Solastalgia and the PHQ

Table 2 shows the scores of solastalgia, somatization, and depressive symptoms. The mean solastalgia score was slightly higher for people living at the pit edge of the open pit mine (18.8 vs. 18.3), though differences were not significant. Binary categorized by gender, female persons reached higher solastalgia scores (19.0 in new villages and 20.1 in pit edge villages) compared to male counterparts (17.5 in new villages and 17.4 in pit edge villages).

The PHQ scores were higher for respondents living in pit edge villages for both somatic (8.3 vs. 6.6,  $p < 0.05$ ) and depressive symptoms (5.2 vs. 4.4), though differences were only significant for somatization. When gender-categorized, this significance remained in female respondents. In both scales and groups, female respondents always reached higher scores than male counterparts. Female persons living in pit edge villages showed the overall highest somatization (9.8 SD 6.2,  $p < 0.05$ ) and depression scores (6.0, SD 5.5). Female persons reported also higher symptom severity after dichotomization in moderate-to-severe symptom levels. At least moderate levels of somatic symptoms were reported by 40.0% of respondents in pit edge villages (e.g., compared to 23.7% in new villages;  $p < 0.05$ ). More than one in two female respondents from pit edge villages reported at least moderate somatic symptom levels, and thus twice as much as did female resettlers (50.5% vs. 25.0%;  $p < 0.05$ ). In general, considerably less participants reported moderate-to-severe symptom levels for depression (12.8–20.6%) than they did for somatization (22.5–50.5%).

A moderate positive correlation between solastalgia and somatic symptoms ( $r = 0.45$  for new villages and  $r = 0.51$  for pit edge villages), respectively depressive symptoms ( $r = 0.46$  for new villages and  $r = 0.52$  for pit edge villages), was found (all  $p < 0.001$ ), with a strong correlation in the group of the pit edge villages.

There was no clear correlation detected between the period since completed resettlement and solastalgia, depression, or somatic symptoms, respectively (data not shown).

### Resettlement process and outcomes

65.9% of the resettled people indicated that their living conditions improved due to resettlement, see Table 3. Every second participant (49.5%) felt well informed/ advised by authorities during the resettlement process. Almost half (47.8%) of the people responded that they are looking ahead with a better feeling than before resettlement. On the other hand, 41.3% of the resettlers would have liked to spend the rest of their lives in their old village. Participants indicated a (strong) physical (33.0%) and psychological exhaustion (23.3%) due to the resettlement process. Two out of five respondents (41.1%) faced additional financial burden, while 28.3% said they lost contact with cherished people after relocation.

	New villages <sup>a</sup>	Pit edge villages	p-Value*
Solastalgia (score)			
Mean (SD)			
Solastalgia	18.3 (7.8) n = 98	18.8 (7.6) n = 224	n.s. <sup>#</sup>
Male	17.5 (8.1) n = 50	17.4 (7.9) n = 110	n.s. <sup>#</sup>
Female	19.0 (7.4) n = 48	20.1 (7.2) n = 111	n.s. <sup>#</sup>
PHQ (score)			
Mean (SD)			
Somatization	6.6 (6.2) n = 93	8.3 (6.4) n = 213	<0.05 <sup>#</sup>
Male	6.2 (6.5) n = 49	6.9 (6.3) n = 103	n.s. <sup>#</sup>
Female	7.0 (5.8) n = 44	9.8 (6.2) n = 109	<0.05 <sup>#</sup>
Depression	4.4 (4.9) n = 91	5.2 (5.4) n = 210	n.s. <sup>#</sup>
Male	4.4 (5.2) n = 48	4.4 (5.2) n = 102	n.s. <sup>#</sup>
Female	4.5 (4.7) n = 43	6.0 (5.5) n = 107	n.s. <sup>#</sup>
PHQ (dichotomized score > 9)			
n (%)			
Somatization > 9	22 (23.7%) n = 93	85 (40.0%) n = 213	<0.05
Male	11 (22.5%) n = 49	30 (29.1%) n = 103	n.s.
Female	11 (25.0%) n = 44	55 (50.5%) n = 109	<0.05
Depression > 9	15 (16.5%) n = 91	35 (16.7%) n = 210	n.s.
Male	9 (18.8%) n = 48	13 (12.8%) n = 102	n.s.
Female	6 (14.0%) n = 43	22 (20.6%) n = 107	n.s.
PHQ and Solastalgia (correlations)			
r (n) *			
Somatization and solastalgia	0.45 (93)	0.51 (213)	<0.001
Depression and solastalgia	0.46 (91)	0.52 (210)	<0.001

**Table 2.** Solastalgia and Patient Health Questionnaire (PHQ) scores. <sup>a</sup> data refers to original location of residence (prior to resettlement), where relevant; \*chi-square or (<sup>#</sup>) Kruskal-Wallis test; n.s. = not significant; SD = standard deviation; r = Spearman correlation coefficient.

### Impacts of and attitudes towards open pit mining

Table 4 shows positive and negative attitudes towards open pit mining. Over half of the resettlers (55.6%) indicated an understanding for open pit mining, in contrast to 43.0% of residents from pit edge villages. Less than half of both groups were satisfied with the authorities' efforts to monitor the environmental impacts of open pit mining (42.4% in new villages vs. 47.3% in pit edge villages). 36.9% of the people from pit edge villages responded that they cannot/ could not enjoy life as much due to the open pit mine (vs. 33.0% of the people living in new villages). More than half of the respondents from pit edge villages (51.1%) were concerned that their health may be threatened by open pit mining in contrast to only 28.6% from the new villages. 52.0% of the resettlers (strongly) agreed on feeling 'agitated/ angry about demonstrations' (vs. 43.3%). In terms of place attachment (see Table 4), respondents from pit edge villages indicated a deeper connection to their village, a higher sense of responsibility for locals and a more than three times (63.4% vs. 18.7%) greater duty to maintain their place for future generations, compared to resettlers (when referring to their original place of residence).

### Environmental hazards

Figure 3 lists potential environmental hazards related to open pit mining, responded by people living in pit edge villages. People felt most affected by dust (76.2% experienced it often to nearly always), followed by noise from the open pit mine (41.9%). Also, noise from demonstrations in the context of the open pit mine was experienced often to nearly always by one-fifth (19.1%) of respondents on a frequent basis. More than 85% of participants stated they were rarely or never affected by noise or vibration from resettlement activities.

	n (%) <sup>*</sup>
Positive aspects	
Feeling more comfortable in new village	38 (41.8%) n = 91
Improved living conditions after resettlement	60 (65.9%) n = 91
Feeling well informed by authorities during resettlement process	45 (49.5%) n = 91
Looking ahead with a better feeling than before resettlement	44 (47.8%) n = 92
Negative aspects	
Feeling physically exhausted	30 (33.0%) n = 91
Feeling psychologically exhausted	21 (23.3%) n = 90
Extra financial burden	37 (41.1%) n = 90
Lost contact with cherished people	26 (28.3%) n = 92
Resisted the resettlement for a long time	25 (27.2%) n = 92
Would have liked to spend the rest of my life in my old village	38 (41.3%) n = 92

**Table 3.** Resettlement process and outcomes (responded by residents from new villages). \* % of answers with ‘strongly agree’ or ‘agree’.

### Environmental and community actions

The undertaken actions responding to the open pit mine vary between the groups of residents and resettlers (shown Fig. 4). For both groups, the most commonly reported activity was attending village community meetings, though more than twice as much among resettlers, compared to pit edge village respondents (67.0% vs. 31.7%). Frequently mentioned actions among people from new villages were contact to politicians (37.6%) and statements made in press/ broadcast (27.1%). Among pit edge village participants, the support of community initiatives against the open pit mine (24.5%) and taking part in local environmental or building protection measures (18.2%) were more common. Altogether, 48 participants (15.4%) declared having participated at least once in a demonstration against open pit mining.

### Free text comments

At the end of the questionnaire, respondents could annotate comments on the survey or elaborate on their personal situation. Just over 100 people took this opportunity. The following themes were emphasized or added on a frequent basis:

- Heavy exposure to dust from open pit mining.
- Sad feelings about the clearing and defragmentation of the Hambach Forest.
- Recultivated spoil pile (Sophienhöhe) – balanced positive and negating comments.
- Occupation of the forest by activists causes discomfort for some participants.
- Incomplete resettlement of one pit edge village led to anger and injustice.
- Additional mental burden through the COVID-19 pandemic and war in Ukraine.

### Discussion

Our study examined the living situation, mental health and specific stressor among residents and resettlers such as environmental degradation and the resettlement process associated with the open pit mine Hambach in Western Germany. Therefore, experienced effects of open pit mining and possible relocation, feelings of solastalgia and the presence of somatic and depressive symptoms were enquired. The mean scores of solastalgic, somatic and depressive symptoms as well as the frequency of moderate-to-severe symptom levels were higher among people still residing at the open pit mine in pit edge villages, compared to resettlers. Whether for depression, somatization or solastalgia, female respondents always reached higher scores than male counterparts. This trend, was already observed in previous studies<sup>44–46</sup>, even among open pit mining communities<sup>47</sup> i.e. also in previous research in the Rhenish lignite region<sup>14</sup>.

Comparing the two groups, the sample size of the resettlers was significantly smaller. It should be noted that the population of people living in villages at the edge of the pit is much larger than the group of resettlers. In addition, the study was localized through the use of paper questionnaires and the local newspaper. Therefore, resettlers who have moved much further away may not have been reached by our survey, at all. In addition, some resettlers could have closed the matter with the move and do not want to be reminded of this for some quite emotional happening by taking part in surveys.

Comparing our findings with the general population, we found considerably increased levels in our both mining affected study groups:

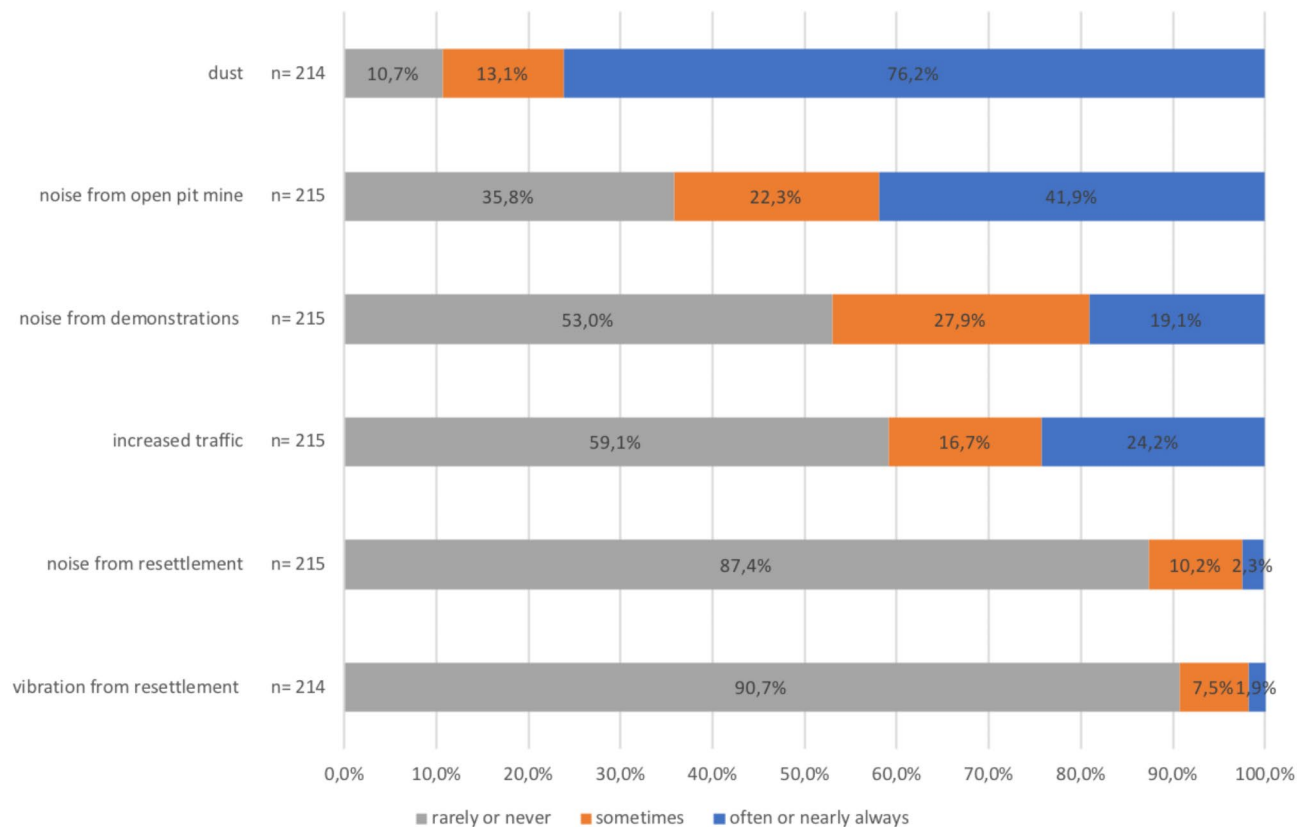
	New villages <sup>#</sup>	Pit edge villages
	n (%)	
Positive aspects		
Understanding for open pit mining	55 (55.6%) n = 99	98 (43.0%) n = 228
Economic advantages are important for the region	64 (65.3%) n = 98	130 (57.0%) n = 228
Financing of community projects by the mining company is helpful for the region	67 (67.7%) n = 99	143 (63.3%) n = 226
Satisfied with the efforts of the authorities to monitor the environmental impact of open pit mining	42 (42.4%) n = 99	104 (47.3%) n = 220
Negative aspects		
Could not enjoy my life as much through the open pit mining	33 (33.0%) n = 100	84 (36.9%) n = 228
Disagreements about open pit mine in		
Family	17 (17.0%) n = 100	23 (10.0%) n = 229
Village	30 (30.0%) n = 100	83 (36.6%) n = 227
Angry about destroyed		
Natural habitat for plants and animals	52 (52.5%) n = 99	133 (58.3%) n = 228
Historic buildings and landmarks	40 (40.0%) n = 100	120 (52.4%) n = 229
Effects of open pit mining are depressing	30 (30.6%) n = 98	76 (34.1%) n = 223
Agitated/ angry about demonstrations	51 (52.0%) n = 98	97 (43.3%) n = 224
Concerned that my health may be threatened by open-pit mining	28 (28.6%) n = 98	114 (51.1%) n = 223
Place attachment		
Feeling a deep connection to the place	41 (44.6%) n = 92	116 (54.4%) n = 213
Feeling a sense of responsibility for the people in the place	24 (26.4%) n = 91	103 (48.4%) n = 213
Feeling I have a duty to maintain the place for future generations	17 (18.7%) n = 91	135 (63.4%) n = 213

**Table 4.** Attitudes towards open pit mining. \* % of answers with ‘strongly agree’ or ‘agree’; # data refer to original location of residence (prior to resettlement), where relevant.

According to the latest representative data in Germany from 2021, 8.8% of women and 7.5% of men in Germany reported at least moderate depressive symptoms (using the PHQ-8 questionnaire with a range of 0–24; cut-off score likewise  $\geq 10$ )<sup>48</sup>. In our study cohorts, the values were higher, around twice as much for all (16.5–16.7%), as well as separated for females (20.6–14.0%) and males (18.8–12.8%). According to the latest data (2017) concerning the frequency of somatic symptoms in the general population, the mean PHQ-15 score (ranged from 0 to 28) was 5.5 (4.62 for males and 6.31 for females)<sup>46</sup>. Thus, in our study population scores were about 20% (new villages) to 50% (pit edge villages) higher (6.6 among resettlers and 8.8 in pit edge villages). These findings suggest that the observed association of open pit mining on the living environment and everyday life may be a potential psychological stress factor for local communities.

The concept of solastalgia originated in an Australian region that underwent increasing environmental impacts through open pit mining<sup>33</sup>. The meaning of solastalgia becomes more distinct, when looking at the more severe symptoms experienced by respondents from pit edge villages, i.e. who still live very close to the open pit mine. Solastalgic feelings refer to the ‘powerlessness’ experienced when your familiar surrounding environment changes, not when you change your surroundings (relocate)<sup>33</sup>. When communities remain living at their original home place, their relationship to that place may decline, when it loses its integrity<sup>33</sup>. The strong positive correlation between solastalgia and depressive or somatic symptoms found for open pit mine residents in this study underlines the psychological component within the concept of solastalgia. A strong feeling of solastalgia is therefore likely to contribute to the emergence or aggravation of mental disorders. Interestingly, no clear correlation was found between the period since completed resettlement and the respective symptom scores of solastalgia, depression and somatization, in the new villages group, similar to the study by Krueger in the Rhenish region<sup>14</sup>. One reason for this could be a too small study population of the resettlers. Otherwise, it suggests that “time does not heal all wounds” and psychological impairment may persist through the years. In light of this, the need for (long-term) psychosocial support services at community and individual level, seems even more necessary, to mitigate or prevent mental illness and improve general quality of life<sup>46</sup>.

Respondents from pit edge villages were stronger attached to their places (e.g., connection to place, responsibility for local people), than were resettlers to their original villages. The continuous alterations of the



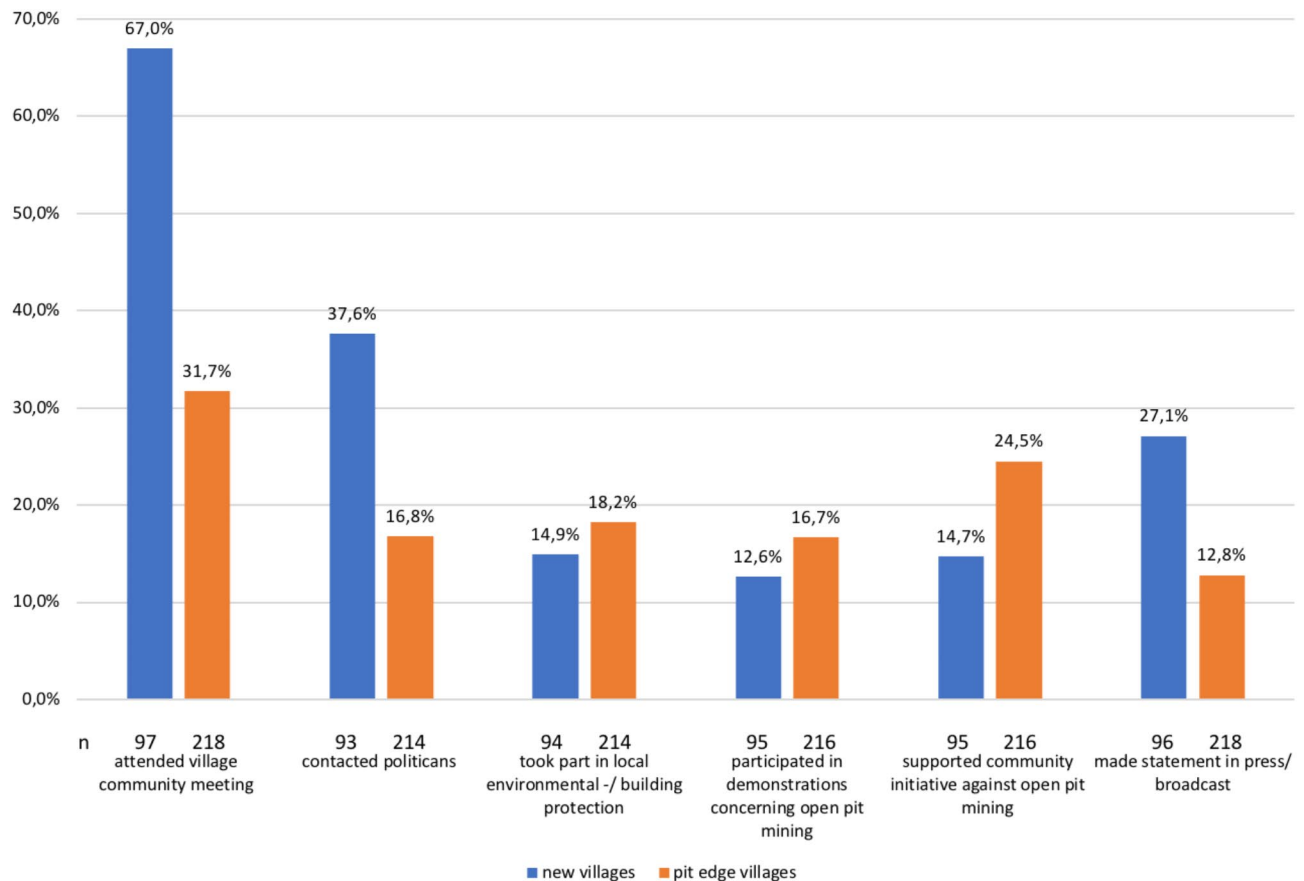
**Fig. 3.** Frequency of experienced environmental hazards of respondents from pit edge villages.

old place itself, resulting from the expanding open pit mine, resettlement activities and building demolitions, may reinforce the erosion of emotional memories and attachment for both groups. However, the data suggest that by changing location, the connection to the original place diminishes considerably. Higginbotham et al. already showed that people with a higher place attachment had stronger feelings of solastalgia, consistent with our data<sup>15</sup>. The importance of an established home becomes apparent by looking at the free text comments of our questionnaire. For participants who lived in the village of Morschenich and resettled before it was announced Morschenich will not be demolished and the resettlements won't be completed<sup>49</sup>, the main stated problem was the lacking possibility of reversing their resettlement by re-buying their old family home, but there are no clear sources regarding this topic. That new unknown people will live in their former traditional home, gave those resettlers a feeling of betrayal and injustice as described in our free text fields.

Mapping the current literature in Germany, Krueger et al. have already examined the mental health of communities at the neighboring open pit mine Garzweiler in the Rhenish region<sup>14</sup>. Although local and temporal circumstances differ in their study (e.g., resettlement process less advanced, with an additional third study group of individuals who were still to be resettled), the spatial proximity, similar sociodemographic characteristics and legal contexts of mining and resettlements, allows to draw comparisons: In line with our findings, higher scores of solastalgia, depression and somatization were found in the pit edge villages group, compared to new villages participants. There was also a similar trend in gender differences (female participants reported stronger psychological symptoms) and environmental hazards (dust as the most common problem). In general, the communities in proximity to the Garzweiler open pit mine reported higher scores in all psychological scales as well as solastalgia, than in this study. Taking into account the current conditions of the two locations, one explanatory approach for these differences lies within the time passed since completed resettlement. At the Hambach open pit mine, the resettlements took place years earlier and are now almost completed, whereas at the Garzweiler open pit mine they are a much more topical issue<sup>50</sup>. The latter could provoke more insecurity and psychological burden for all locals involved, explaining the higher symptoms levels at Garzweiler. Also, the ongoing resettlements at the open pit mine Garzweiler are associated with more activism on-site<sup>51</sup>. As seen in our study, the reactions of the residents to activism could also include feelings of stress, though this varies widely between respondents.

Also, the finding of our study in Germany cannot be generalized to open pit mines in other countries. Different local as well as cultural conditions need to be considered here. Further aspects influencing the well-being of affected populations could be sociodemographic factors, current recultivation measures and support systems, political situation (activism, groups who are still to be resettled) and pre-existing mental health status.

Dust, noise and increased traffic due to the open pit mine were the most frequently mentioned environmental hazards in this study. The estimation of the experienced frequency is naturally very subjective, depending on the



**Fig. 4.** Environmental/ community actions that have been undertaken by the respondents split into the two groups.

person's perception and vulnerability, exact place of residence, etc. Regardless, it has been proven that noise as well as (perceived) environmental pollution in general, can negatively impact the mental health of individuals<sup>30,31</sup>. For instance, Seidler et al. showed a positive relation between traffic noise and the risk of a newly diagnosed depression<sup>11</sup>. Taking the geographical location into account, the well-being of residents of the pit edge village Buir may also be affected by the proximity to the highway<sup>12</sup>, which is a source of noise and impaired air quality.

Most resettlers and pit edge village residents confirmed having attended a village community meeting concerning the open pit mining, though twice as much resettlers did so (67.0% vs. 31.7%). One reason for this could be that active participation in the resettlement process was supposedly intended by the companies/ authorities involved<sup>52</sup>, thus meeting spaces were presumably actively offered for those to be relocated. On the other hand, a will for a greater collective self-determination, cohesion and exchange during the resettlement seems plausible. In the process of relocation, it is important for the people concerned to make decisions about the location or infrastructure of the new village, in order to have some kind of control over their future and better deal with the consequences of environmental degradation<sup>23,53</sup>.

Regarding the resettlement process, only half of the resettlers (49.5%) felt well-informed by authorities. Access to information on planned procedures and available options during resettlement, as well as the role of autonomous decision-making, seem to be crucial for a successful relocation<sup>53</sup>.

Several limitations must be considered when interpreting our results. First, there is a huge difference in the number of participants of the two groups studied, with only  $n = 100$  respondents from new villages. Due to the study design, and in particular by the use of an online questionnaire, no sufficient response rate can be estimated. Also, since the average resettlement was completed around 10 years ago, we cannot exclude recall bias. Further, PHQ-9 & -15 are self-reported, so there might be reporting biases, likely to rather overestimate the prevalence of depression or somatization<sup>54</sup>. Important to note, the PHQ-9 & -15 do not make definitive diagnoses of mental disorders. In addition, the questionnaire does not consider current events such as the COVID-19 pandemic or the conflict in Ukraine possibly amplifying symptoms of depression or somatization. Previous studies found that psychological stress, depression and anxiety symptoms increased since the beginning of the COVID-19 pandemic<sup>55,56</sup>. Our data collection took place in April and May 2022, when infection incidences and population-wide restrictions were low; nevertheless, the pandemic situation could have impacted our findings. Given that very recent population representative data (2021) on depression were available<sup>48</sup>, our results remain conclusive even under the influence of the COVID-19 pandemic. The recent war in Ukraine may have had a greater impact

on the mental state on the general population, including our study group, but due to a lack of data precise effects cannot yet be estimated.

Mental health is influenced by further factors, including education, income, family and relationships, as well as physical health. In our cohort, although a high percentage of participants reported having university degree, a high PHQ symptom score was observed, although a higher education goes along with a lower likelihood of depressive symptoms<sup>57</sup>. Here, the belonging to the place and the influence of a changing environment could contribute to that fact. Physical health was not queried, a statement on the relation between physical and mental health can therefore not be derived in our cohort.

Due to the cross-sectional study design, no clear causal relationship between psychological distress and open pit mining can be inferred. The proximity of individual new villages to the open pit mine is also a matter of concern, as it could have an impact on their well-being. In addition, resettlers did not provide any information on potential environmental hazards in their new home. The questionnaire also may have missed relevant aspects, e.g., the profession and socioeconomic status (thus adaptability potential) of respondents. Especially in the vicinity of the open pit mine, occupational dependencies on the mining company cannot be ruled out and could have distorted our findings.

Participation in studies can be influenced by several variables. Data shows that an old age and a lower physical functioning has a negative impact on study participation<sup>58</sup>. This is particularly important as the group of resettlers includes more elderly, as relocation processes at the Hambach open pit mine have been carried out for a long time. Lower levels of income and a lower education makes it less likely that a person will complete the full questionnaire. Also, health problems are strong factors influencing participation in trials<sup>59</sup>. However, depression is not significantly related to study participation when examined alone<sup>58</sup>.

Furthermore, governmental efforts to mitigate the negative impacts of coal mining must also be taken into account as they can have an influence on attitudes towards open pit mining. To name just a few: financial assistance under the Structural Strengthening Act is to benefit local infrastructure in the affected region as well as renaturation and reforestation of former open pit mining areas<sup>60</sup>. Furthermore, innovative projects of communities, universities or companies are tried to be included in the design of the Rhineland area<sup>61</sup>.

The results of this study reveal a need for psychosocial support for local people affected by open pit mining and resettlement. In accordance with the recent findings of Kruger et al., the data from this study demonstrate higher symptom levels of psychological distress in residents who live or have lived right next to an open pit mine in comparison to the general population<sup>14</sup>. The elevated scores of those relocated, in this study often about a decade ago, also indicate that psychological distress, when present, can be long-term, extending beyond the period of active resettlement and familiarization with the new place. Especially for countries that still expand coal mining or other large-scale infrastructure projects, these findings give cause to early take care of the mental health of affected communities and to engage in dialogue with them. Extending communal or individual support services can be one possible undertaken measure, though the needs of those affected must be determined and respected according to their individual circumstances. Further research should focus on the resettlement processes themselves and how they can be made more socially and economically acceptable for local communities. Moreover, fair compensations for experienced environmental degradations in the familiar surroundings are considered helpful by the authors.

## Conclusions

The aim of our study was to assess environmental factors potentially affecting the mental health of people living in the vicinity of the Hambach open pit mine.

Both, respondents from pit edge villages and resettlers at the open pit mine Hambach, reported higher than usual depressive and somatic symptom levels and feelings of solastalgia, suggesting an impact of open pit mining and relocation on psychosocial health. Solastalgia, i.e. distress caused by a changing home environment, positively correlated with the symptom levels of depression and somatization. Respondents from pit edge villages felt most frequently affected by dust and noise derived from the open pit mine. 33% of the resettlers stated physically and 23.3% psychologically exhaustion due to the resettlement process. Only every second resident was satisfied with the authorities' efforts to monitor environmental impacts of the open pit mine, while more than half of respondents from pit edge villages had health concerns.

Our data indicates the need for a dialogue with those affected by open pit mining processes including the health and well-being of residents and resettlers, respectively. Prospective studies to investigate causal relations between environmental changes and the mental health status need to be initiated. In addition, our results suggest an extension of implemented support services according to the individual circumstances.

Besides, the elaborated results can assist in developing further resettlement, recultivation and recompensation measures by taking the mental well-being of residents in proximity to open pit mines into account.

## Data availability

The data that support the findings of this study are available from the corresponding author, Emma Holtermann, upon reasonable request.

Received: 15 April 2024; Accepted: 3 March 2025

Published online: 14 March 2025

## References

1. United Nations. Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on its third session, held in Glasgow from 31 October to 13. 2022. November (2021).

2. United Nations. COP26: The Glasgow climate pact. (2021).
3. Arbeitsgemeinschaft Energiebilanzen. Auswertungstabellen zur Energiebilanz Deutschland. Available online: accessed on 16 September 2022) (2021). [https://ag-energiebilanzen.de/wp-content/uploads/2022/04/awt\\_2020\\_d.pdf](https://ag-energiebilanzen.de/wp-content/uploads/2022/04/awt_2020_d.pdf)
4. Deutscher Bundestag. Entwurf eines Gesetzes zur Reduzierung und zur Beendigung der Kohleversorgung und zur Änderung weiterer Gesetze (Kohleausstiegsgesetz). Available online: September (2022). <https://dserver.bundestag.de/btd/19/173/1917342.pdf> (accessed on 22 2020).
5. Die Bundesregierung Koalitionsvertrag 2021–2025 zwischen der Sozialdemokratischen Partei Deutschlands (SPD), BÜNDNIS 90 / DIE GRÜNEN und den Freien Demokraten (FDP). Available online: (2021). <https://www.bundesregierung.de/resource/blob/974430/1990812/04221173eef9a6720059cc353d759a2b/-12-10-koav2021-data.pdf?download=1> (accessed on 26 September 2022). 2021.
6. Petsonk, E. L., Rose, C. & Cohen, R. Coal mine dust lung disease. New lessons from old exposure. *Am. J. Respir. Crit. Care Med.* **187**, 1178–1185. <https://doi.org/10.1164/rccm.201301-0042CI> (2013).
7. Hall, N. B., Hallidin, C. N., Blackley, D. J. & Laney, A. S. Assessment of pneumoconiosis in surface coal miners after implementation of a National radiographic surveillance program, united States, 2014–2019. *Am. J. Ind. Med.* **63**, 1104–1108. <https://doi.org/10.1002/ajim.23184> (2020).
8. Centers for Disease, Control and Prevention. Pneumoconiosis and advanced occupational lung disease among surface coal miners—16 States, 2010–2011. *MMWR Morb Mortal. Wkly. Rep.* **61**, 431–434 (2012).
9. Souza, M. R. et al. Environmental exposure to mineral coal and by-products: influence on human health and genomic instability. *Environ. Pollut.* **287** <https://doi.org/10.1016/j.envpol.2021.117346> (2021).
10. Brisbois, B. W. et al. *Mapping research on resource extraction and health: A scoping review* (Elsevier, 2019).
11. Seidler, A. et al. Association between aircraft, road and railway traffic noise and depression in a large case-control study based on secondary data. *Environ. Res.* **152**, 263–271. <https://doi.org/10.1016/j.envres.2016.10.017> (2017).
12. Orban, E. et al. Residential road traffic noise and high depressive symptoms after five years of Follow-up: Results from the heinz Nixdorf recall study. *Environ. Health Perspect.* **124**, 578–585. <https://doi.org/10.1289/ehp.1409400> (2016).
13. Beutel, M. E. et al. Noise annoyance is associated with depression and anxiety in the general Population- the contribution of aircraft noise. *PLoS One* **11**, e0155357. <https://doi.org/10.1371/journal.pone.0155357> (2016).
14. Kruger, T., Kraus, T., Kaifie, A. A. & Changing home a cross-sectional study on environmental degradation, resettlement and psychological distress in a Western German Coal-Mining region. *Int. J. Environ. Res. Public Health.* **19** <https://doi.org/10.3390/ijerph19127143> (2022).
15. Higginbotham, N., Connor, L., Albrecht, G., Freeman, S. & Agho, K. Validation of an environmental distress scale. *EcoHealth* **3**, 245–254. <https://doi.org/10.1007/s10393-006-0069-x> (2006).
16. Mactaggart, F., McDermott, L., Tynan, A. & Gericke, C. A. Exploring the determinants of health and wellbeing in communities living in proximity to coal seam gas developments in regional Queensland. *BMC Public Health.* **18**, 51. <https://doi.org/10.1186/s12889-017-4568-1> (2017).
17. Hossain, D. et al. Impact of the mining industry on the mental health of landholders and rural communities in Southwest Queensland. *Australas Psychiatry* **21**, 32–37. <https://doi.org/10.1177/1039856212460287> (2013).
18. Wang, Z. et al. Modelling regional ecological security pattern and restoration priorities after long-term intensive open-pit coal mining. *Sci. Total Environ.* **835**, 155491. <https://doi.org/10.1016/j.scitotenv.2022.155491> (2022).
19. Wu, Z., Lei, S., Yan, Q., Bian, Z. & Lu, Q. Landscape ecological network construction controlling surface coal mining effect on landscape ecology: A case study of a mining City in semi-arid steppe. (2021).
20. Skaloš, J. & Kašparová, I. Landscape memory and landscape change in relation to mining. (2012).
21. Hota, P. & Behera, B. Coal mining in Odisha: An analysis of impacts on agricultural production and human health. (2015).
22. Van Haaften, E. H. & Van De Vijver, F. J. Psychological consequences of environmental degradation. *J. Health Psychol.* **1**, 411–429. <https://doi.org/10.1177/135910539600100401> (1996).
23. Van Haaften, E. H. & Van de Vijver, F. J. Dealing with extreme environmental degradation: Stress and marginalization of Sahel dwellers. *Soc. Psychiatry Psychiatr Epidemiol.* **34**, 376–382. <https://doi.org/10.1007/s001270050158> (1999).
24. Kohleausstieg, J. V. December : Wie sich das Rheinische Revier neu erfinden will. Available online: (2022). <https://www.nationalgeographic.de/umwelt/2022/02/kohleausstieg-wie-sich-das-rheinische-revier-neu-erfinden-will> (accessed on 1 National Geographic 2022).
25. Bundesverband Braunkohle. Braunkohle in Deutschland. Available online: (2021). [https://braunkohle.de/wp-content/uploads/2021/04/DEBRIV\\_Statistikflyer-2021-final.pdf](https://braunkohle.de/wp-content/uploads/2021/04/DEBRIV_Statistikflyer-2021-final.pdf) (accessed on 7 September 2022).
26. RWE Power Aktiengesellschaft. Änderung des Braunkohlenplans Teilplan 12/1 Tagebau Hambach aus Anlass der Leitentscheidung der Landesregierung NRW vom 23.03.2021. Available online: (2021). <https://www.rwe.com/-/media/RWE/documents/01-der-koernern/betriebsstandorte/tagebau-hambach/vorhabenbeschreibung.pdf> (accessed on 9 September 2022).
27. Leue, V. December Demonstrationen für den Erhalt des Hamb. Available online: (2022). <https://www.deutschlandfunk.de/hambacher-forst-demonstrationen-fuer-den-erhalt-des-hambi-100.html> (accessed on 1 2018).
28. Forschungsstelle Rekultivierung. Rekultivierung im Rheinischen Braunkohlenrevier Exkursionsführer. Available online: (2014). <https://www.forschungsstellerekultivierung.de/downloads/exkursionsfuehrerteilii201405.pdf> (accessed on 8 September 2022).
29. Speldewinde, P. C., Cook, A., Davies, P. & Weinstein, P. A relationship between environmental degradation and mental health in rural Western Australia. *Health Place* **15**, 865–872. <https://doi.org/10.1016/j.healthplace.2009.02.011> (2009).
30. Ventriglio, A. et al. Environmental pollution and mental health: A narrative review of literature. *CNS Spectr.* **26**, 51–61. <https://doi.org/10.1017/S1092852920001303> (2021).
31. Yamashita, T., Kim, G., Liu, D. & Bardo, A. R. Associations between perceived environmental pollution and mental health in middle-aged and older adults in East Asia. *Asia Pac. J. Public Health* **33**, 109–112. <https://doi.org/10.1177/1010539520960993> (2021).
32. Albrecht, G. et al. Solastalgia: The distress caused by environmental change. *Australas Psychiatry.* **15** (Suppl 1), 95–98. <https://doi.org/10.1080/10398560701701288> (2007).
33. Albrecht, G. & 'Solastalgia' A new concept in health and identity. *PAN: Philos. Activism Nat.* (2005).
34. Connor, L. et al. Environmental change and human health in upper hunter communities of New South Wales, Australia. *EcoHealth* **2004**.
35. Leiner, D. J. SoSci Survey (Version 3.3.17) [Computer software]. Available at <https://www.socisurvey.de>. Available online: (accessed on 11 September 2022).
36. Kroenke, K., Spitzer, R. L. & Williams, J. B. The PHQ-9: validity of a brief depression severity measure. *J. Gen. Intern. Med.* **16**, 606–613. <https://doi.org/10.1046/j.1525-1497.2001.016009606.x> (2001).
37. Kroenke, K., Spitzer, R. L. & Williams, J. B. The PHQ-15: Validity of a new measure for evaluating the severity of somatic symptoms. *Psychosom. Med.* **64**, 258–266. <https://doi.org/10.1097/00006842-200203000-00008> (2002).
38. Eisenman, D., McCaffrey, S., Donatello, I. & Marshal, G. An ecosystems and vulnerable populations perspective on solastalgia and psychological distress after a wildfire. *Ecohealth* **12**, 602–610. <https://doi.org/10.1007/s10393-015-1052-1> (2015).
39. Warsini, S., Buettner, P., Mills, J., West, C. & Usher, K. The psychosocial impact of the environmental damage caused by the MT Merapi eruption on survivors in Indonesia. *Ecohealth* **11**, 491–501. <https://doi.org/10.1007/s10393-014-0937-8> (2014).
40. Galway, L. P., Beery, T., Jones-Casey, K. & Tasala, K. Mapping the solastalgia literature: A scoping review study. *Int. J. Environ. Res. Public Health.* **16** <https://doi.org/10.3390/ijerph16152662> (2019).

41. Sitnikova, K. et al. Systematic review of measurement properties of questionnaires measuring somatization in primary care patients. *J. Psychosom. Res.* **103**, 42–62. <https://doi.org/10.1016/j.jpsychores.2017.10.005> (2017).
42. El-Den, S., Chen, T. F., Gan, Y. L., Wong, E. & O'Reilly, C. L. The psychometric properties of depression screening tools in primary healthcare settings: A systematic review. *J. Affect. Disord.* **225**, 503–522. <https://doi.org/10.1016/j.jad.2017.08.060> (2018).
43. Kroenke, K., Spitzer, R. L., Williams, J. B. & Lowe, B. The patient health questionnaire somatic, anxiety, and depressive symptom scales: A systematic review. *Gen. Hosp. Psychiatry* **32**, 345–359. <https://doi.org/10.1016/j.genhosppsych.2010.03.006> (2010).
44. Kocalevent, R. D., Hinze, A. & Brahler, E. Standardization of a screening instrument (PHQ-15) for somatization syndromes in the general population. *BMC Psychiatry* **13**, 91. <https://doi.org/10.1186/1471-244X-13-91> (2013).
45. Kocalevent, R. D., Hinze, A. & Brahler, E. Standardization of the depression screener patient health questionnaire (PHQ-9) in the general population. *Gen. Hosp. Psychiatry* **35**, 551–555. <https://doi.org/10.1016/j.genhosppsych.2013.04.006> (2013).
46. Hinze, A. et al. Frequency of somatic symptoms in the general population: normative values for the patient health Questionnaire-15 (PHQ-15). *J. Psychosom. Res.* **96**, 27–31. <https://doi.org/10.1016/j.jpsychores.2016.12.017> (2017).
47. Hendryx, M. I. W. K.A. *Increased risk of depression for people living in coal mining areas of central appalachia* (Ecopsychology, 2013).
48. Robert Koch Institut. *Gesundheitliche Lage der erwachsenen Bevölkerung in Deutschland - Ergebnisse der Studie GEDA 2019/2020-EHIS*. Available online: September (2022). [https://www.rki.de/DE/Content/Gesundheitsmonitoring/Gesundheitsberichterstattung/GBEDownloadsJ/JoHM\\_03\\_2021\\_GEDA\\_2019\\_2020\\_EHIS.pdf?\\_\\_blob=publicationFile](https://www.rki.de/DE/Content/Gesundheitsmonitoring/Gesundheitsberichterstattung/GBEDownloadsJ/JoHM_03_2021_GEDA_2019_2020_EHIS.pdf?__blob=publicationFile) (accessed 9 September 2022).
49. Hambach, R. W. E. T. *Hambacher Forst wird nicht in Insellage geplant - Morschenich soll bergbaulich nicht in Anspruch genommen werden*. Available online: (2020). <https://www.rwe.com/-/media/RWE/documents/07-presse/rwe-power-ag/2020/20-01-2020-stellungnahme-zum-tagebau-hambach.pdf> (accessed on 8 September 2022).
50. RWE. *Tagebau Hambach - Hauptbetriebsplan für den Zeitraum 01.01.2021 bis 12.12.2024*. Available online: September (2022). <https://www.rwe.com/-/media/RWE/documents/10-nachbarschaft/hauptbetriebsplan-tagebau-hambach/hauptbetriebsplan-kurzinfo.pdf> (accessed on 10 September 2022).
51. Aachener Zeitung. *Die Lage in Lützerath von A bis Z*. Available online: December (2022). [https://www.aachener-zeitung.de/lokal/es/heinsberg/die-lage-in-luetzerath-von-a-bis-z\\_aid-80029435](https://www.aachener-zeitung.de/lokal/es/heinsberg/die-lage-in-luetzerath-von-a-bis-z_aid-80029435) (accessed on 1 December 2022).
52. RWE. *Planung und Durchführung der Umsiedlung*. Available online: December (2022). <https://www.rwe.com/nachbarschaft/rwe-vor-ort/umsiedlung/planung-und-durchfuehrung> (accessed on 1 December 2022). <https://www.rwe.com/nachbarschaft/rwe-vor-ort/umsiedlung/planung-und-durchfuehrung> (accessed on 10 September 2022).
53. Adams, H., Alaniz, R., Bronen, R. & McNamara, K. *Maintaining and building 'place' through managed and forced community relocations: Lessons for a climate changed worldp.* 23 (United Nations University Institute of Environment and Human Security, 2015).
54. Levis, B. et al. Patient health Questionnaire-9 scores do not accurately estimate depression prevalence: Individual participant data meta-analysis. *J. Clin. Epidemiol.* **122**(e111), 115–128. <https://doi.org/10.1016/j.jclinepi.2020.02.002> (2020).
55. Jia, R. et al. Mental health in the UK during the COVID-19 pandemic: Cross-sectional analyses from a community cohort study. *BMJ Open*. **10**, e040620. <https://doi.org/10.1136/bmjopen-2020-040620> (2020).
56. Peters, A. R., Greiser, S., Dallavalle, K. H. & Berger, M. K. The impact of the COVID-19 pandemic on Self-Reported health: early evidence from the the German National cohort. *Dtsch. Arztebl Int.* (2020).
57. Kondirulli, F. & Sunder, N. Mental health effects of education. *Health Econ.* **31**(Suppl 2), 22–39. <https://doi.org/10.1002/hec.4565> (2022).
58. Beller, J., Geyer, S. & Epping, J. Health and study dropout: health aspects differentially predict attrition. *BMC Med. Res. Methodol.* **22**, 31. <https://doi.org/10.1186/s12874-022-01508-w> (2022).
59. Goldberg, M., Chastang, J. F., Zins, M., Niedhammer, I. & Leclerc, A. Health problems were the strongest predictors of attrition during follow-up of the GAZEL cohort. *J. Clin. Epidemiol.* **59**, 1213–1221. <https://doi.org/10.1016/j.jclinepi.2006.02.020> (2006).
60. Bundesrat. *Strukturstärkungsgesetz Kohleregionen - Vom 8. August 2020*. (2020).
61. GmbH, Z. R. R. & Förderprogramm March - „Revier. Gestalten. Available online: (2023). <https://www.rheinisches-revier.de/wie/foerderung/revier-gestalten/> (accessed on 6 September 2023).

## Acknowledgements

We thank all participants for filling out our questionnaire and their insightful comments.

## Author contributions

Conceptualization, E.H., T.K. (Theresa Krüger), A.K.; methodology, E.H., T.K. (Theresa Krüger), A.K.; formal analysis, E.H.; resources, E.H.; writing - original draft preparation, E.H.; writing - review and editing, E.H., T.K. (Theresa Krüger), T.K. (Thomas Kraus), A.K.; visualization, E.H.; supervision, A.K.; All authors have read and agreed to the published version of the manuscript.

## Funding

Open Access funding enabled and organized by Projekt DEAL.

## Declarations

## Competing interests

T.K. (Theresa Krüger) is member of the German Alliance on Climate Change and Health (Deutsche Allianz Klimawandel und Gesundheit e.V.) and the Health for Future movement. There are no other conflicts of interest declared by all other authors.

## Ethics approval

The study was conducted in accordance with the Declaration of Helsinki, and approved by the local Human Research Ethics Committee of the RWTH Aachen University, Faculty of Medicine (EK094-22, 7 March 2022).

## Informed Consent

Informed consent was obtained from all subjects involved in the study.

## Additional information

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1038/s41598-025-92834-8>

[0.1038/s41598-025-92834-8](https://doi.org/10.1038/s41598-025-92834-8).

**Correspondence** and requests for materials should be addressed to E.H.

**Reprints and permissions information** is available at [www.nature.com/reprints](http://www.nature.com/reprints).

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2025

**Solastalgia (Score)**

	New villages	Pit edge villages
	n (%*)	
sense of belonging undermined by mining-induced changes	26 (26,5%) n= 98	37 (16,6%) n= 223
sad that native nature is being destroyed	54 (55,1%) n= 98	145 (64,7%) n= 224
worried that valued aspects of place—clean air, scenery—are being lost	43 (43,9%) n= 98	137 (61,4%) n= 223
miss peace and quiet once enjoyed in this place	40 (40,8%) n= 98	75 (33,5%) n= 224
sad when look at mine voids and degraded landscapes	41 (41,8%) n= 98	116 (51,8%) n= 224
farming lifestyle depending on good land and water is threatened by mining-induced changes	37 (37,8%) n= 98	104 (46,6%) n= 223

**Table S1.** Items for calculating the solastalgia score

\*% of answers with 'strongly agree' or 'agree'

## Allgemeine Informationen zur Studie

**Worum geht es?** Im Rahmen meiner Doktorarbeit möchte ich untersuchen, inwiefern sich die Veränderungen von Heimat und Umwelt im Rheinischen Braunkohlerevier auf Gesundheit und Wohlbefinden der betroffenen Menschen auswirken.

**Teilnahmevoraussetzungen:** Sie sind mindestens 18 Jahre alt und aktuell in einer Ortschaft in der Nähe des Tagebaus Hambach wohnhaft oder waren vor Ihrer Umsiedlung in den vergangenen Jahren dort wohnhaft.

**Zeitdauer:** Die Bearbeitung dieses Fragebogens wird etwa 15 bis 20 Minuten dauern.

**Anonymität:** Alle Angaben, die Sie hier machen, werden anonym gespeichert und verarbeitet. Das bedeutet, dass zu keinem Zeitpunkt irgendwelche Angaben auf Sie persönlich zurückgeführt werden können.

**Kontakt:** Bei Fragen, Problemen oder Ähnlichem können Sie mich gern kontaktieren unter [emma.holtermann@rwth-aachen.de](mailto:emma.holtermann@rwth-aachen.de) oder 015774204913.

**Bei Nichtteilnahme entstehen für Sie keinerlei Nachteile!**

Mit dem Ausfüllen dieses Fragebogens bestätigen Sie, dass Sie die oben angegebenen Informationen gelesen und verstanden haben und mit der anonymen Verarbeitung Ihrer Daten einverstanden sind.

## Wichtige Hinweise zur Bearbeitung der Fragen

Verlassen Sie sich auf Ihre erste Reaktion und beantworten Sie die Fragen spontan.

Es gibt keine richtigen oder falschen Antworten. Bitte antworten Sie so, wie es für Sie am besten zutrifft. Bitte antworten Sie offen und ehrlich.

Bitte lassen Sie keine Frage aus. Sollten Sie einmal nicht die perfekt passende Antwort finden können, so wählen Sie bitte diejenige, die am ehesten auf Sie zutrifft.

Wenn Sie weiterführende Anmerkungen oder Rückmeldungen zum Fragebogen machen möchten, nutzen Sie dafür bitte das Freitextfeld auf der letzten Seite.

**Diese Studie schließt nur Personen ein, die in einer Ortschaft am Tagebau  
Hambach wohnhaft sind bzw. waren!**

**Wie alt sind Sie?**

..... Jahre

**Welchem Geschlecht ordnen Sie sich zu?**

- männlich
- weiblich
- divers
- Ich möchte keine Angabe machen

**Welche Angabe trifft auf ihren aktuellen Familienstand zu?**

- ledig
- in einer Partnerschaft
- verheiratet
- verwitwet
- geschieden

**Welcher ist Ihr höchster Schulabschluss?**

- Haupt- oder Volksschulabschluss
- Realschule oder Polytechnische Hochschule
- Fachhochschulreife/ Abschluss einer Fachoberschule
- Abitur
- Schule beendet ohne Abschluss

**Welchen höchsten beruflichen Ausbildungs- bzw. Hochschulabschluss haben Sie?**

- Schüler:in
- noch in beruflicher Ausbildung (Auszubildene:r, Student:in, Berufsvorbereitungsjahr)
- keinen Berufsabschluss und nicht in beruflicher Ausbildung
- beruflich-betriebliche Ausbildung (Lehre) abgeschlossen
- beruflich-schulische Ausbildung (Berufsfachschule, Handelsschule) abgeschlossen
- Ausbildung an einer Fachschule, Meister-, Technikerschule, Berufs- oder Fachakademie abgeschlossen
- Bachelor an (Fach-) Hochschule abgeschlossen
- sonstiger Abschluss an einer Fachhochschule oder Ingenieurschule
- sonstiger Abschluss an einer Universität oder Hochschule
- anderer Bildungsabschluss

**Was trifft am ehesten auf Ihre momentane Wohnsituation zu?**

- Ich bin vor ..... Jahr(en) und ..... Monaten umgesiedelt und ...
  - ich lebe in einer der Neusiedlungen (z.B. Neu-Etzweiler, Manheim-Neu, Morschenich-Neu)
  - ich lebe nicht in einer der Neusiedlungen
- Ich lebe in einer Ortschaft am Tagebau ohne Umsiedlerstatus (z.B. Niederzier, Merzenich)

1. Die folgenden Fragen beziehen sich auf das **Leben an Ihrer ursprünglichen Ortschaft**. Sollten Sie ggf. umgesiedelt sein, beziehen Sie sich bei der Beantwortung bitte auf Ihre vorherige Ortschaft.

**Wie lange leb(t)en Sie in Ihrer Ortschaft?**

- mein gesamtes Leben
- nicht mein gesamtes Leben, sondern ..... Jahre

**Wie viele Generationen Ihrer Familie lebten schon im Rheinischen Revier?**

- schon die Generation vor meinen Urgroßeltern
- meine Urgroßeltern
- meine Großeltern
- meine Eltern
- Ich bin in meiner Generation in die Region gezogen

**Leb(t)en Sie in einem Haus, einer Wohnung oder auf einem Grundstück, das von früheren Generationen Ihrer Familie bewohnt wurde?**

- ja
- nein

**Ich wohn(t)e in einem/r...**

- Haus/ Wohnung im eigenen oder familiären Besitz
- Haus/ Wohnung zur Miete

**Haben Sie Kinder? Wenn ja, wo leben diese? (Mehrfachauswahl möglich)**

- Ich habe Kinder,
  - die im gleichen Haushalt leben wie ich.
  - die in der gleichen Ortschaft leben wie ich.
  - die in der näheren Umgebung leben (<10 km).
  - die weiter entfernt leben (>10 km).
- Ich habe keine Kinder.

**Haben Sie Enkelkinder? Wenn ja, wo leben diese?** (Mehrfachauswahl  
möglich)

- o Ich habe Enkelkinder,
  - o die im gleichen Haushalt leben wie ich.
  - o die in der gleichen Ortschaft leben wie ich.
  - o die in der näheren Umgebung leben (<10 km).
  - o die weiter entfernt leben (>10 km).
- o Ich habe keine Enkelkinder.

2. Folgend finden Sie Aussagen zu den **persönlich empfundenen Auswirkungen des Tagebaus**. Bitte geben Sie an, inwieweit diese Aussagen für Sie zutreffen/nicht zutreffen.

	trifft zu	trifft eher zu	teils-teils	trifft eher nicht zu	trifft nicht zu
<b>Ich habe Verständnis für den Ausbau des Tagebaus.</b>					
<b>Die wirtschaftlichen Vorteile des Tagebaus (z.B. Arbeitsplätze) für die Region sind wichtig.</b>					
<b>Ich föhl(t)e mich durch den Tagebau <u>nicht</u> persönlich beeinträchtigt in ...</b>					
... wirtschaftlicher Hinsicht					
... gesundheitlicher Hinsicht					
<b>Ich kann/konnte das Leben wegen der Auswirkungen des Tagebaus nicht so sehr genießen, wie ich es gern möchte.</b>					
<b>Meine Ortschaft ist/war durch Meinungsverschiedenheiten über den Tagebau gespalten.</b>					
<b>Meine Familie ist/war durch Meinungsverschiedenheiten über den Tagebau gespalten.</b>					
<b>Ich bin verärgert über die Zerstörung von historischen Gebäuden und Wahrzeichen durch den Tagebau.</b>					
<b>Ich bin verärgert über die Zerstörung von Wohnhäusern durch den Tagebau.</b>					

	trifft zu	trifft eher zu	teils-teils	trifft eher nicht zu	trifft nicht zu
Ich bin verärgert über die Zerstörung von natürlichem Lebensraum für Pflanzen und Tiere durch den Tagebau.					
Es stört mich, dass bei der Erweiterung des Tagebaus künftige Generationen nicht mehr mitbedacht werden.					
Die Finanzierung von Gemeinschaftsprojekten durch das Tagebauunternehmen ist hilfreich für die Region.					
Ich bin besorgt, dass meine Gesundheit durch den Tagebau bedroht sein könnte.					
Ich fühle mich machtlos gegenüber den Veränderungen meiner Heimat.					
Ich bin zufrieden mit den Bemühungen der Behörden, die Umweltfolgen des Tagebaus zu überwachen.					
Die Auswirkungen des Tagebaus in der Region deprimieren mich.					
Durch den Tagebau und die damit einhergehenden Veränderungen, wurde mein Gefühl, zu dieser Ortschaft zu gehören, beeinträchtigt.					
Ich fühle mich aufgewühlt/ bin verärgert über die Demonstrationen.					

	trifft zu	trifft eher zu	teils-teils	trifft eher nicht zu	trifft nicht zu
Ich bin traurig, dass durch den Tagebau heimische Natur zerstört wird.					
Ich bin besorgt, dass Aspekte dieses Ortes, die ich schätze, verloren gehen (z.B. saubere Luft, schöne Landschaften)					

	Trifft zu	Trifft eher zu	Teils-teils	Trifft eher nicht zu	Trifft nicht zu
Ich vermisse das Gefühl von Frieden und Ruhe, das ich früher einmal in dieser Ortschaft genossen habe.					
Ich bin traurig, wenn ich Tagebaulöcher und zerstörte Landschaften betrachte.					
Ich fürchte, dass durch den Tagebau die regionale Landwirtschaft geschädigt wird.					

3. Bitte geben Sie an, ob Sie eine der genannten **Aktivitäten als Reaktion auf die Auswirkungen des Tagebaus** in Ihrer Region durchgeführt haben.

	ja	nein
Meinungsäußerung in Presse oder Rundfunk getätigt		
Teilnahme an einem Treffen der Dorfgemeinschaft zur Diskussion der Tagebauauswirkungen		
Ich stand aufgrund meiner Bedenken zu den Auswirkungen des Tagebaus in Kontakt mit		
... politischen Amtsinhaber:innen		
... rechtlichen Vertreter:innen oder Institutionen		
... Umweltbehörden oder -verbänden		
... dem Tagebauunternehmen		
Petition gegen den Ausbau des Tagebaus unterschrieben		
Teilgenommen an lokalen Umwelt- oder Gebäudeschutzmaßnahmen		
Teilgenommen an Demonstrationen gegen den Tagebau		
Unterstützung einer Bürgerinitiative, die sich gegen den Ausbau des Tagebaus einsetzt		

4. Die folgenden Aussagen richten sich nur an Teilnehmende, die eine **Umsiedlung bereits vollständig abgeschlossen** haben.

**Alle anderen Teilnehmenden gehen bitte weiter zu Box 5.**

Bitte geben Sie an, inwieweit diese Aussagen für Sie zutreffen/ nicht zutreffen.

	trifft zu	trifft eher zu	teils-teils	trifft eher nicht zu	trifft nicht zu
In meiner neuen Ortschaft fühle ich mich wohler als in meiner alten Ortschaft.					
Ich blicke mit einem besseren Gefühl in die Zukunft als vor der Umsiedlung.					
Ich hätte mein weiteres Leben gern in meiner alten Ortschaft verbracht.					
Ich fühle noch eine tiefe Verbundenheit zu meiner alten Ortschaft.					
Ich habe mich innerlich lange gegen die Umsiedlung gewehrt.					
Ich fühle mich weiterhin für die Menschen in meiner alten Ortschaft verantwortlich.					
Ich <u>wünsche mir</u> , dass meine alte Ortschaft noch für zukünftige Generationen erhalten bleibt.					
Ich <u>fühle mich verpflichtet</u> , meine alte Ortschaft noch für zukünftige Generationen zu erhalten.					
Durch die Umsiedlungen habe ich Kontakt zu mir liebgewonnenen Menschen verloren.					
Die Umsiedlung belastet mich psychisch oder hat mich psychisch belastet.					
Ich fühle oder fühlte mich durch die Umsiedlung körperlich erschöpft.					
Die Umsiedlung ging für mich mit einer finanziellen Mehrbelastung einher.					
Meine berufliche Situation hat sich durch die Umsiedlung verschlechtert.					
Die Ausübung meiner Freizeitaktivitäten hat sich durch die Umsiedlung verschlechtert (z.B. Vereinsaktivität, Sport, Spaziergänge).					

	Trifft zu	Trifft eher zu	Teils-teils	Trifft eher nicht zu	Trifft nicht zu
Durch die Umsiedlung haben sich meine allgemeinen Lebensbedingungen verbessert (z.B. altersgerechtes Wohnen oder nahe Einkaufsmöglichkeiten)					
Während des Umsiedlungsprozesses fühlte ich mich von den verantwortlichen Stellen gut informiert, beraten und unterstützt.					
Es belastet mich, dass meine alte Ortschaft vielleicht erhalten bleibt und nicht abgerissen wird.					
Die Gemeinschaft in der neuen Ortschaft zeigt einen stärkeren Zusammenhalt als vor der Umsiedlung.					
Ich fühle mich in der neuen Ortschaft mehr durch die Umwelt belastet als in meiner alten Ortschaft (z.B. durch Baulärm).					

	trifft zu	trifft eher zu	teils-teils	trifft eher nicht zu	trifft nicht zu
Bitte beantworten Sie die Frage nur, wenn Sie <u>Nutztiere</u> besitzen: <b>Meine Nutztiere kann ich in der neuen Ortschaft genauso gut halten wie früher.</b>					

	ja	nein	keine Angabe
<b>Die Umsiedlung ging für mich mit dem Verlust von Grundstücksfläche oder Land einher.</b>			
Bitte beantworten Sie die Frage nur, wenn Sie <u>Nutztiere</u> besitzen: <b>Vor der Umsiedlung besaßen ich und meine Familie mehr Nutztiere.</b>			

5. Die folgenden Aussagen richten sich nur an Teilnehmende, die in einer **Ortschaft ohne Umsiedlerstatus** am Tagebau leben, also nicht von Umsiedlung betroffen sind.

Alle anderen Teilnehmenden gehen bitte weiter zu Box 6.

Bitte geben Sie an, inwieweit diese Aussagen für sie zutreffen/ nicht zutreffen.

	trifft zu	trifft eher zu	teils-teils	trifft eher nicht zu	trifft nicht zu
Ich fühle eine tiefe Verbundenheit zu dieser Ortschaft.					
Ich empfinde eine gewisse Verantwortung für die Menschen an dieser Ortschaft.					
Ich fühle mich verpflichtet, meine Ortschaft noch für zukünftige Generationen zu erhalten.					
Die Veränderungen durch den Tagebau beeinflussen meine Lebenssituation negativ.					
Aufgrund der Veränderungen durch den Tagebau würde ich meine Ortschaft verlassen, wenn ich könnte.					

Folgend finden Sie Umgebungsbelastungen durch den Tagebau, die Sie in Ihrer Ortschaft möglicherweise erleben bzw. erlebt haben. Bitte geben Sie an, wie oft Sie diese erleben bzw. erlebt haben.

	nie	selten	manchmal	oft	fast immer
Staub (z.B. Kohlestaub)					
Lärm durch <u>Tagebauaktivitäten</u> (z.B. Lastwagen)					
Vibration oder Erschütterung durch <u>Tagebauaktivitäten</u> (z.B. Schaufelradbagger)					
Lärm durch <u>Umsiedlungen</u> (z.B. Häuserabriss)					
Vibration oder Erschütterung durch <u>Umsiedlungen</u> (z.B. Häuserabriss)					

	Nie	Manchmal	Selten	Oft	Fast immer
Nächtliche Lichtbelästigung durch Tagebauaktivitäten					
Erhöhtes Verkehrsaufkommen (z.B. durch Umleitungen)					
Lärm durch <u>Demonstrationen</u> (z.B. Hubschrauber)					

	ja	nein	keine Angabe
Bergschäden an ihrer/m Wohnung/Haus oder Grundstück			

6. Die folgenden Aussagen richten sich an **alle Teilnehmenden**.  
Bitte geben Sie an, wie stark Sie sich im Verlauf der letzten **4 Wochen** durch die folgenden **Beschwerden** beeinträchtigt gefühlt haben.

	Nicht beeinträchtigt	Wenig beeinträchtigt	Stark beeinträchtigt
Bauchschmerzen			
Rückenschmerzen			
Schmerzen in den Armen, Beinen oder Gelenken (Knie, Hüften usw.)			
Falls zutreffend: <b>Menstruationsschmerzen oder andere Probleme bei der Menstruation</b>			
Schmerzen oder Probleme beim Geschlechtsverkehr			
Kopfschmerzen			
Schmerzen im Brustbereich			
Schwindel			
Ohnmachtsanfälle			
Herzklopfen oder Herzrasen			
Kurzatmigkeit			
Verstopfung, nervöser Darm oder Durchfall			

	Nicht beeinträchtigt	Wenig beeinträchtigt	Stark beeinträchtigt
Übelkeit, Blähungen oder Verdauungsbeschwerden			

7. Die folgenden Aussagen richten sich an **alle Teilnehmenden**.  
Bitte geben Sie an, wie oft Sie sich im Verlauf der letzten **2 Wochen** durch die folgenden **Beschwerden** beeinträchtigt gefühlt haben.

	Überhaupt nicht	An einzelnen Tagen	An mehr als der Hälfte der Tage	Beinahe jeden Tag
Nervosität, Ängstlichkeit oder Anspannung				
Nicht in der Lage sein, Sorgen zu stoppen oder zu kontrollieren				
Übermäßige Sorgen bezüglich verschiedener Angelegenheiten				
Schwierigkeiten zu entspannen				
Rastlosigkeit, so dass Stillsitzen schwer fällt				
Schnelle Verärgerung oder Gereiztheit				
Gefühl der Angst, so als würde etwas Schlimmes passieren				
Wenig Interesse / Freude an Ihren Tätigkeiten				
Niedergeschlagenheit, Schwermut oder Hoffnungslosigkeit				
Schwierigkeiten, ein- oder durchzuschlafen, oder vermehrter Schlaf				
Müdigkeit oder das Gefühl, keine Energie mehr zu haben				
Verminderter Appetit oder das übermäßige Bedürfnis zu essen				
Schlechte Meinung von sich selbst; Gefühl ein Versager zu sein oder die Familie enttäuscht zu haben				

	Überhaupt nicht	An einzelnen Tagen	An mehr als der Hälfte der Tage	Beinahe jeden Tag
Schwierigkeiten, sich auf etwas zu konzentrieren, z.B. beim Zeitungslesen oder Fernsehen				
Waren Ihre Bewegungen und Ihre Sprache so verlangsamt, dass es auch anderen auffallen würde? Oder waren Sie im Gegenteil „zappelig“ oder ruhelos und hatten dadurch einen stärkeren Bewegungsdrang als sonst?				
Gedanken, dass Sie lieber tot wären oder sich Leid zufügen möchten				

8. Bitte nutzen Sie für weiterführende **Anmerkungen, Erklärungen oder Kommentare** zu Ihrer persönlichen Situation oder zum Fragebogen das folgende Freitextfeld (optional).

Sollten Sie beim Ausfüllen dieses Fragebogens bemerkt haben, dass Sie sich durch die Auswirkungen des Tagebaus und Veränderungen Ihrer Heimat gesundheitlich stark belastet fühlen und möglicherweise professionelle Unterstützung benötigen, wenden Sie sich bitte an Dr. Andrea Kaifie- Pechmann (Institut für Arbeits-, Sozial und Umweltmedizin, Uniklinik RWTH Aachen) zur weiteren Beratung: [akaifie@ukaachen.de](mailto:akaifie@ukaachen.de) oder 0241 / 8035345.

**Vielen Dank für Ihre Teilnahme an dieser Studie!**

**Bitte senden Sie den Fragebogen innerhalb von zwei  
Wochen in dem vorfrankierten Umschlag zurück an:**

PD Dr. med. Andrea Kaifie-Pechmann und Emma Holtermann

Institut für Arbeits-, Sozial- und Umweltmedizin

Uniklinikum RWTH Aachen

Pauwelsstraße 30

52074 Aachen

## **Danksagung**

An dieser Stelle möchte ich allen beteiligten Personen meinen großen Dank aussprechen, die mich bei der Anfertigung meiner Dissertation unterstützt haben.

Mein besonderer Dank gilt Prof. Dr. Andrea Kaifie-Pechmann für ihr fachliches Feedback und die hervorragende Betreuung bei der Durchführung der gesamten Arbeit.

Ebenso möchte ich Dr. Theresa Krüger meinen Dank aussprechen, die meine Arbeit durch ihre Anregungen, Unterstützung und Gedanken geprägt hat.

Mein Dank geht zudem an Univ.-Prof. Dr. Kraus, der meine Arbeit durch seine Unterstützung ermöglicht hat.

Neben der fachlichen Unterstützung möchte ich besonders bei meinen Eltern und Geschwistern bedanken, die mich in jeder Phase meines Studiums ermutigt und motiviert haben.

## **Erklärung § 5 Abs. 1 zur Datenaufbewahrung**

Hiermit erkläre ich, dass die dieser Dissertation zu Grunde liegenden Originaldaten in dem Institut für Arbeits-, Umwelt- und Sozialmedizin des Universitätsklinikums Aachen hinterlegt sind.

## Erklärung gemäß § 5 Abs. (1) und (2), und § 11 Abs. (3) 12. der Promotionsordnung

Hiermit erkläre ich, **Emma Holtermann**, an Eides statt, dass ich den wesentlichen Anteil an der Publikation:

**Emma Holtermann**, Theresa Krüger, Thomas Kraus, Andrea Kaifie: Community perceptions and mental burdens among (former) residents at Europe's largest lignite mine in Western Germany: a cross-sectional study; Scientific Reports.; 2025, 15, 14(11) geleistet habe.

Die Anteile an der Arbeit waren wie folgt:

	Emma Holtermann	Theresa Krüger	Thomas Kraus	Andrea Kaifie-Pechmann	Summe (%)
Studienüberwachung				100	100
Studienkonzeption	40	30		30	100
Methode	50	25		25	100
Datenerhebung	100				100
Formale Analyse	100				100
Statistische Auswertung	70			30	100
Visualisierung	100				100
Datenverwaltung	100				100
Interpretation der Datenauswertung	80			20	100
Verfassung des Manuskripts	100				100
Korrektur des Manuskripts	50	20	10	20	100

Aus diesem wesentlichen Anteil ergibt sich selbstverständlich die Stellung als Erstautorin.

\_\_\_\_\_  
Doktorandin Emma Holtermann

Als Doktormutter bestätige ich die Angaben von Emma Holtermann

\_\_\_\_\_  
Prof. Dr. Andrea Kaifie-Pechmann

Ich schliesse mich der Erklärung von Prof. Dr. Andrea Kaifie-Pechmann als Koautor an

\_\_\_\_\_  
Dr. Theresa Krüger

\_\_\_\_\_  
Univ.-Prof. Dr. Thomas Kraus