Preventive Medicine Reports 48 (2024) 102913

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Determinants of persistent smoking among breast cancer survivors

Kathleen Gali [a,b,*], Sita Aryal [b,c], Frederike Bokemeyer [d,e], Sabine Behrens [f], Petra Seibold [f], Nadia Obi [g,h], Heiko Becher [i], Jenny Chang-Claude [b,f]

[a] Hamburg Center for Health Economics (HCHE), University of Hamburg, Hamburg, Germany
[b] Cancer Epidemiology Group, University Cancer Center Hamburg (UCCH), University Medical Center Hamburg-Eppendorf (UKE), Hamburg, Germany
[c] Department of Health Sciences, Faculty of Life Sciences, Hamburg University of Applied Sciences, Hamburg, Germany
[d] Institute for Medical Psychology, University Cancer Center Hamburg (UCCH), University Medical Center Hamburg-Eppendorf, Hamburg, Germany
[e] Department of Oncology, Hematology with Section Bone Marrow, Transplantation, and Pneumology, University Cancer Center Hamburg (UCCH), University Medical Center Hamburg-Eppendorf, Hamburg, Germany
[f] Division of Cancer Epidemiology, German Cancer Research Center (Deutsches Krebsforschungszentrum, DKFZ), Heidelberg, Germany
[g] Institute for Medical Biometry and Epidemiology (IMBE), University Medical Center Hamburg-Eppendorf (UKE), Hamburg Germany
[h] Institute for Occupational and Maritime Medicine, University Medical Center Hamburg-Eppendorf (UKE), Hamburg, Germany
[i] Heidelberg Institute of Global Health, University Hospital Heidelberg, Heidelberg, Germany

ARTICLE INFO

Keywords:
Determinants of cigarette smoking
Breast cancer
Breast cancer survivors
Cancer prevention
Prevention and epidemiology
Behavioral science

ABSTRACT

Introduction: While quitting cigarette smoking can improve cancer treatment outcomes, many cancer patients continue to smoke post-diagnosis. The aim of this study was to examine factors associated with persistent cigarette use in postmenopausal women diagnosed with breast cancer, a cancer not traditionally thought of as tobacco-related. Methods: We used data of breast cancer patients who were recruited into the MARIE Study (Mamma Carcinoma Risk Factor Investigation) in Germany between 2002 and 2005 and followed up in 2009. This analysis was based on 450 study participants who reported active cigarette smoking at the time of diagnosis and participated in the follow-up interview. Logistic regression analyses were conducted to examine the association of sociodemographic characteristics, health behaviors, medical factors, and cancer treatment types with persistent smoking behavior. Results: At an average of 5.9 years (SD = 1.2) after diagnosis, 244 (54.2%) breast cancer survivors were still smoking cigarettes at follow-up. A longer duration of smoking (OR = 1.04, 95% CI = 1.01–1.06) and smoking on average ≥10 cigarettes per day (OR = 1.52, 95% CI = 1.02–2.28) increased the likelihood of persistent smoking, whereas increasing age (OR = 0.94, 95% CI = 0.90–0.97) and high engagement in leisure time physical activity (≥62 MET-hrs/wk: OR = 0.55, 95% CI = 0.32–0.98) were associated with quitting. Conclusion: Smoking cessation programs in cancer care are needed. Specifically for breast cancer patients, tobacco treatment plans that include physical activity may be particularly helpful in quitting smoking cigarettes.

1. Introduction

Breast cancer is the most common cancer in women, both in Germany and globally (Robert Koch Institute, 2023; World Health Organization, 2023). While breast cancer survival rates have significantly increased due to improvements in detection methods and targeted treatments (Robert Koch Institute, 2023), persistent tobacco smoking after a breast cancer diagnosis may increase the risk for all-cause and cancer-specific mortality (Passarelli et al., 2016; Pierce et al., 2014; Wang et al., 2016). The risk of cancer recurrence and postoperative complications are increased with persistent tobacco smoking (Bishop et al., 2014; Padubidri et al., 2001). Despite these risks, a notable proportion of cancer patients, including those with breast cancer, continue to smoke post-diagnosis (Gummerson et al., 2022; Paul et al., 2019; U.S. Department of Health and Human Services, 2020). Women diagnosed with breast cancer may not consider smoking cessation as a means of improving clinical outcomes since this cancer is not traditionally thought of as tobacco-related.

While a cancer diagnosis can serve as a teachable moment to motivate behavior change, substantial support is needed to sustain smoking cessation (Park et al., 2020). Smoking cessation interventions include behavioral therapy (i.e., counselling), which can be done individually or

* Corresponding author at: University of Hamburg, Hamburg Center for Health Economics (HCHE), Hamburg, Germany
E-mail address: Kathleen.gali@uni-hamburg.de (K. Gali).

https://doi.org/10.1016/j.pmedr.2024.102913
Received 22 May 2024; Received in revised form 14 October 2024; Accepted 15 October 2024
Available online 20 October 2024

in a group, and pharmacotherapy (i.e., nicotine replacement gum) which helps to reduce uncomfortable feelings and cravings associated with nicotine withdrawal (Centers for Disease Control and Prevention, 2021). The combined use of pharmacotherapy with behavioral therapy are recommended and is feasible to support cancer survivors to quit smoking (Park et al., 2020; U.S. Department of Health and Human Services, 2020).

However, effective smoking cessation interventions for cancer survivors remain a challenge. A *meta*-analysis in 2019 that included 21 randomized clinical trials focused on interventions for smoking cessation in cancer survivors found an effect size close to zero ($d = 0.030$; 95% CI = −0.042–0.101) (Sheeran et al., 2019). One reason smoking cessation interventions were shown to be ineffective could be due to the lack of targeted interventions (Sheeran et al., 2019). For example, research has found non-small cell lung cancer survivors were more likely to quit smoking compared to those with cancers generally considered as non-smoking-related such as breast cancer (Gummerson et al., 2022), and therefore may require different intervention approaches and elements (Sheeran et al., 2019). Tailoring smoking cessation interventions by age group and genders may also be beneficial as the determinants of smoking vary (Allen et al., 2014, 2016; Hall et al., 2008; Kim et al., 2021).

Few studies have investigated determinants of persistent smoking after a cancer diagnosis, and those that have were based on pooled analysis of multiple cancer types or focused mainly on smoking-related cancers such as lung and head and neck cancer or were based on a small convenient sample (Bryant et al.; Gallaway et al., 2019; Koo et al., 2020; Malburg et al., 2020; Schnoll et al., 2011; Swoboda et al., 2019; Westmaas et al., 2014). In this study, we aimed to identify factors associated with persistent smoking among postmenopausal breast cancer survivors, which may be useful in developing targeted smoking cessation interventions. We examined the associations of sociodemographic characteristics (i.e., age, education, marital status, region), health behaviors (i.e., average number of cigarettes smoked per day, duration of smoking, pack-years, alcohol consumption, leisure time physical activity), medical factors (i.e., body mass index, comorbidities) and cancer treatment types (i.e., radiotherapy, chemotherapy) with persistent smoking in postmenopausal breast cancer survivors.

2. Methods

2.1. Study population

We used data of breast cancer patients recruited in the Mamma Carcinoma Risk Factor Investigation (MARIE) study, which was a population-based case-control study conducted in two regions of Germany: Hamburg and Rhine-Neckar-Karlsruhe. Eligible patients were German speaking, 50–74 years old and had histologically confirmed first primary invasive (stage I to IV) or in situ breast cancer between January 1, 2001 and September 30, 2005 (Flesch-Janys et al., 2008). Patients were identified from participating clinics and the Hamburg cancer registry. Participants provided written informed consent, completed a standardized face-to-face interview at recruitment, and were followed up using computer assisted telephone interviews in 2009. The study was approved by the ethics committees of the University of Heidelberg, the Hamburg Medical Council, and the Medical Board of the state of Rhineland-Palatinate and conducted in accordance with the Declaration of Helsinki.

Those patients who were actively smoking at diagnosis and participated in the follow-up were included in this study. We excluded 2006 women who at recruitment reported that they never smoked or smoked less than 100 cigarettes in their lifetime, 1054 women who formerly smoked cigarettes but quit one year before breast cancer diagnosis or earlier, leaving 755 women who were labeld as currently smoking. Of these, we excluded 122 women who had died during follow-up, 2 who migrated during follow-up, 178 who did not participate in the follow-up interview, and 1 participant with missing sociodemographic information. Data analysis therefore included 450 women who reported active smoking within the year preceding the breast cancer diagnosis. A flow diagram of the inclusion and exclusion criteria of study participants is presented in Fig. 1.

2.2. Variables of interest

Information on sociodemographic characteristics, health behaviors, and medical factors were collected during the baseline interview or through medical reports.

2.2.1. Sociodemographic characteristics

Sociodemographic information included age at diagnosis, educational attainment (low, middle, high), marital status (married/living with a partner or not) and study region (Hamburg or Rhine-Neckar-Karlsruhe).

2.2.2. Health behaviors

The average number of cigarettes smoked per day and the number of years smoked was assessed. Cigarettes per day (cpd) was dichotomized into <10 and ≥10 cpd. The pack-years of cigarettes smoked were calculated by dividing the number of cigarettes smoked per day by 20 (the number of cigarettes per pack), and then multiplying by the number of years smoked. The number of pack-years was then categorized into ≤10, >10-<24, and ≥24 based on tertiles as cutoff points. The data collected on amount, frequency, and type (i.e., beer, wine) of alcohol was used to calculate grams per day of alcohol consumed, as described previously (Vrieling et al., 2012). For analysis, the alcohol variable was dichotomized into <12 and ≥12 g/day, based on the amount of alcohol in a standard drink. Leisure time physical activity was based on the number of hours per week of walking, cycling, and other sports activities from 50 years of age onwards, which was then converted into the metabolic equivalent of task in hours per week (MET-hrs/wk) (Schmidt et al., 2008) and then categorized into quartiles for analysis.

2.2.3. Medical factors including cancer treatment

Self-reported information on body mass index (BMI) was categorized into <18.5 kg/m^2, 18.5 kg/m^2 to <25 kg/m^2, ≥25 kg/m^2 according to WHO criteria. Information provided on comorbidities (based on a proffered list) was used to derive the modified Charlson Comorbidity Index (CCI) which did not include tumors (Möhl et al., 2021). Cancer treatment details (radiotherapy and chemotherapy) were abstracted from the medical records. The histological characteristics of breast cancer (tumor stage, tumor grade, and hormone receptor status) were obtained from pathological reports. Hormone receptor status includes information on estrogen receptor (ER) and progesterone receptor (PR).

2.3. Outcome variable

At follow-up, changes in smoking behaviors after diagnosis were asked using the following question: *"Have you changed your smoking habits after being diagnosed with breast cancer?''*. Response options were: *"No, I have not changed my smoking habits"; "Yes, I have changed my smoking habits: I stopped after the diagnosis", "Yes, I have changed my smoking habits: I smoke heavier now", "Yes, I have changed my smoking habits: I smoke less now"*. Those who reported stopping smoking after the diagnosis were categorized as quit. Those who responded to the other options were grouped and labeled as persistent smoking.

2.4. Statistical analysis

Descriptive statistics of the baseline variables of interests (sociodemographic characteristics, health behaviors, and medical factors including breast cancer treatment) according to smoking status at follow-up (quit versus persistent smoking) were calculated. The

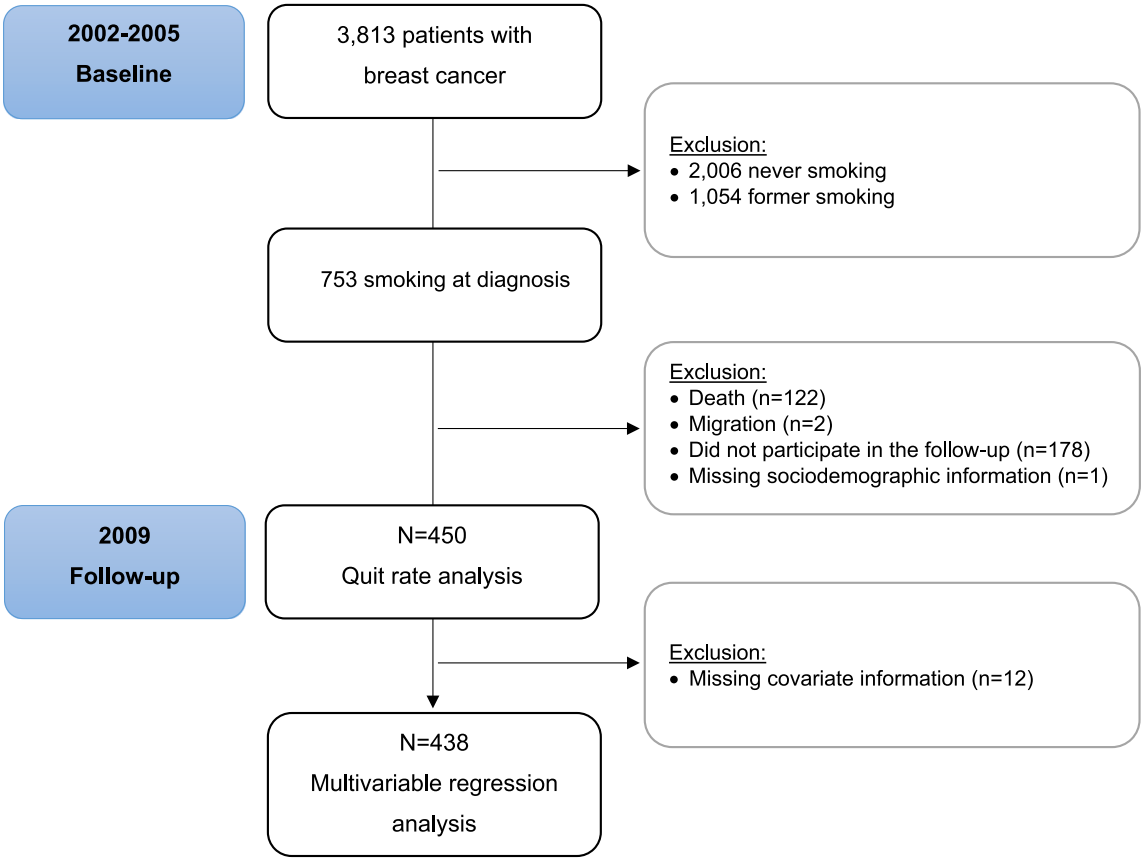

Fig. 1. Flow diagram depicting the criteria for data analysis.

association of individual variables of interest on persistent smoking were assessed by computing odds ratios (OR) and 95% confidence intervals (95% CI). The most important determinants of persistent smoking were then identified from a multivariable model using backward selection method with an inclusion criteria of a p-value <0.15. Pack-years was not included due to its high correlation with cpd and duration of smoking. In the final model, a p-value of less than 0.05 was considered statistically significant. Analyses were performed using the SPSS statistical software, version 29.

3. Results

The average age of the 450 women included in the analysis was 60.0 (standard deviation (SD) = 6.0) years at diagnosis. Nearly half of the women (48.2%) had first stage breast cancer and 65.1% had both estrogen and progesterone hormone receptor positive tumors. About half (54.2%) of the breast cancer survivors who were labeled as currently smoking cigarettes at diagnosis were still smoking after an average of 5.9 (SD = 1.18) years after diagnosis. Among those who continued smoking cigarettes, 56.6% had smoked an average of ≥ 10 cpd and 38.5% had a history of smoking ≥ 24 pack-years. See Table 1.

In univariate analyses, currently smoking ≥10 cpd compared to <10 cpd (OR = 1.75, 95% CI = 1.20–2.55), longer duration of smoking (OR = 1.02, 95% CI = 1.00–1.04), and heavier lifetime smoking compared to ≤10 pack-years (>10-<24 pack-years: OR = 2.69, 95% CI = 1.68–4.31; ≥24 pack-years: OR = 2.74, 95% CI = 1.72–4.37) were significantly associated with a higher risk of persistent smoking in breast cancer survivors (Table 2). Increasing age (OR = 0.97, 95% CI = 0.94–1.00) and greater engagement in leisure physical activity (highest quartile, ≥62 MET-hrs/week: OR = 0.50, 95% CI = 0.29–0.84) compared to the lowest quartile, <24 MET-hrs/week, were associated with quitting smoking. There was no significant association between educational attainment, marital status, alcohol consumption, BMI, CCI, and breast cancer treatment with persistent smoking.

The backward model selection yielded age (OR = 0.94, 95% CI = 0.90–0.97), cpd (≥10 cpd: OR = 1.52, 95% CI = 1.02–2.28), duration of smoking (OR = 1.04, 95% CI = 1.01–1.06), leisure physical activity (≥62 MET- hrs/week: OR = 0.55, 95% CI = 0.32–0.98), educational attainment (medium: OR = 1.24, 95% CI = 0.78–1.96; high: OR = 0.67, 95% CI = 0.39–1.15), and marital status (OR = 0.69, 95% CI = 0.45–1.06) to be relevant determinants of persistent smoking (Table 2). Age, cpd, smoking duration and leisure physical activity showed statistically significant associations.

4. Discussion

In this prospective analysis of postmenopausal women with a history of breast cancer, we evaluated the association of sociodemographic characteristics, health behaviors, and medical factors including cancer treatment with continuing to smoke cigarettes after a breast cancer diagnosis. We found that a a longer duration of smoking, a higher average amount of daily cigarettes smoked at baseline, and high leisure physical activity were the most important modifiable predictors of persistent smoking. Previous research on other patient populations with cancer (Chatzea et al., 2017; Kim et al., 2015; Tseng et al., 2012; Van Heest et al., 2022) has also indicated that a long duration and intense smoking history are related to an increased likelihood of persistent smoking although none of the previous studies specifically investigated breast cancer. It is thus possible that those who continue to smoke after a cancer diagnosis would benefit from a comprehensive smoking cessation program with follow-up meetings (Cox et al., 2003). As repeated cessation attempts are common (Chaiton et al., 2016), multiple follow-up conversations about smoking behavior, as well as cessation therapies, have been found to help cancer patients quit smoking (Park et al., 2020).

Table 1
Descriptive statistics of demographic characteristics, health behaviors, and medical factors of women with breast cancer who smoked at the time of diagnosis (2001–2005) by smoking status at follow-up (2009), MARIE Study, Germany.

	Total Sample (N = 450)		Quit smoking before follow-up (N = 206)		Persistent smoking at follow-up (N = 244)	
	n	%	n	%	n	%
Demographic Characteristics						
Age at diagnosis, mean (SD)	60.0	(6.0)	60.7	(6.1)	59.4	(5.8)
Education						
Low	241	53.6	109	52.9	132	54.1
Medium	126	28.0	53	25.7	73	29.9
High	83	18.4	44	21.4	39	16.0
Married/living with a partner	287	63.8	137	66.5	150	61.5
Region						
Hamburg	271	60.2	130	63.1	141	57.8
Rhine-Neckar-Karlsruhe	179	39.8	76	36.9	103	42.2
Health Behaviors						
Cigarettes per day						
<10	216	48.0	115	55.8	101	41.4
≥10	228	50.7	90	43.7	138	56.6
Missing	6	1.3	1	0.5	5	2.0
Years of smoking, n = 449, mean (SD)	35.2	(9.5)	34.1	(10.4)	36.1	(8.5)
Pack-years						
≤10	149	33.1	93	45.1	56	23.0
>10–23	144	32.0	55	26.7	89	36.5
≥24	151	33.6	57	27.7	94	38.5
Missing	6	1.3	1	0.5	5	2.0
Alcohol (g/day)						
<12	322	71.6	148	71.8	174	71.3
≥12	126	28.0	58	28.2	68	27.9
Missing	2	0.4	0	0	2	0.8
Leisure physical activity (MET-hrs/wk)						
<24	111	24.7	42	20.4	69	28.3
≥24-<40	116	25.8	46	22.3	70	28.7
≥40-<62	101	22.4	51	24.8	50	20.5
≥62	116	25.8	64	31.1	52	21.3
Missing	6	1.3	3	1.5	3	1.2
Medical Factors						
BMI (kg/m^2)						
<18.5	20	4.4	7	3.4	13	5.3
18.5-<25	349	77.6	160	77.7	189	77.5
≥25	81	18.0	39	18.9	42	17.2
CCI						
0	319	70.9	147	71.4	172	70.5
1	108	24.0	48	23.3	60	24.6
≥2	23	5.1	11	5.3	12	4.9
Radiotherapy						
Yes	348	77.3	158	76.7	190	77.9
No	99	22.0	46	22.3	53	21.7
Unknown / missing	3	0.7	2	1.0	1	0.4
Chemotherapy						
Yes	214	47.6	100	48.5	114	46.7
No	233	51.8	104	50.5	129	52.9
Unknown / missing	3	0.7	2	1.0	1	0.4
Tumor stage						
1	217	48.2	96	46.6	121	49.6
2	142	31.6	69	33.5	73	29.9
3 & 4	43	9.6	18	8.7	25	10.2
Neoadjuvant chemo	16	3.6	9	4.4	7	2.9
Stage 0	32	7.1	14	6.8	18	7.4
Tumor grade						
Low	99	22.0	51	24.8	48	19.7
Moderate	215	47.8	91	44.2	124	50.8
High	88	19.6	41	19.9	47	19.3
Hormone receptor status						
ER/PR positive	293	65.1	137	66.5	156	63.9
ER or PR or endocrine therapy positive	61	13.6	25	12.1	36	14.8
ER/PR negative	48	10.7	21	10.2	27	11.1

MET = metabolic equivalent of task; BMI = body mass index; CCI = Charlson Comorbidity Index; ER = estrogen receptor; PR = progesterone receptor.

Despite the health shock of a cancer diagnosis, only 45.8% of breast cancer patients quit after diagnosis. Women with breast cancer have a higher relative 5-year survival rate (88% in 2020) (Robert Koch Institute, 2023) compared to those with cancers such as lung cancer (25% in women in 2020) (Robert Koch Institute, 2022), and breast cancer has not been traditionally considered as tobacco-related. Therefore, breast cancer patients may assume that their cancer is curable or less serious, and that continued smoking after their diagnosis may not strongly influence their health outcomes (Alton et al., 2018). However, research has shown that quitting smoking at and after diagnosis can improve survival (Del Riccio et al., 2023; Passarelli et al., 2016). Furthermore, quitting at any age is beneficial (Centers for Disease Control and

Table 2
Univariate and multivariable associations between demographic characteristics, health behaviors, and medical factors and persistent smoking at follow-up (2009) among women with breast cancer who were smoking at the time of diagnosis (2001–2005), MARIE Study, Germany.

	Univariate model OR (95 % CI)	Multivariable model OR (95 % CI)
Age at diagnosis	0.97 (0.94–1.00)*	0.94 (0.90–0.97)*
Education		
Low	Ref.	Ref.
Medium	1.14 (0.74–1.76)	1.24 (0.78–1.96)
High	0.73 (0.44–1.21)	0.67 (0.39–1.15)
Living situation/marital status		
Not married or living w/ a partner	Ref.	Ref.
Married/living with a partner	0.80 (0.55–1.18)	0.69 (0.45–1.06)
Region		
Hamburg	Ref.	
Rhine-Neckar-Karlsruhe	1.25 (0.85–1.83)	
Cigarettes per day		
<10	Ref.	Ref.
≥10	1.75 (1.20–2.55)*	1.52 (1.02, 2.28)*
Years of smoking	1.02 (1.00–1.04)*	1.04 (1.01, 1.06)*
Pack-years		
≤10	Ref.	
>10-<24	2.69 (1.68–4.31)*	
≥24	2.74 (1.72–4.37)*	
Leisure physical activity (MET-hrs/wk)		
<24	Ref.	Ref.
≥24-<40	0.93 (0.54–1.58)	1.01 (0.57–1.78)
≥40-<62	0.60 (0.35–1.03)	0.70 (0.39–1.25)
≥62	0.50 (0.29–0.84)*	0.55 (0.32–0.98)*
Alcohol (g/day)		
<12	Ref.	
≥12	0.99 (0.66–1.51)	
BMI (kg/m^2)		
18.5-<25	Ref.	
<18.5	1.57 (0.61–4.04)	
>25	0.91 (0.56–1.48)	
CCI		
0	Ref.	
1	1.07 (0.69–1.66)	
≥2	0.93 (0.40–2.18)	
Radiotherapy (yes vs no)	1.04 (0.67–1.63)	
Chemotherapy (yes vs no)	0.92 (0.63–1.33)	

* = $p < 0.05$; Ref. = reference; OR = odds ratio; 95 % CI = 95% confidence interval; MET = metabolic equivalent of task; BMI = body mass index; CCI = Charlson Comorbidity Index.

Prevention, 2023).

Therefore, it is helpful to increase awareness and education about the negative impact of persistent smoking on survival and overall health outcomes among breast cancer survivors. Unfortunately, smoking cessation interventions especially for breast cancer patients hardly exist in Germany. Germany is considered one of the most inactive countries in Europe regarding the implementation of comprehensive tobacco control measures and smoking cessation interventions (Joossens et al., 2022). Barriers to access evidence-based treatment include a lack of referral to cessation services (Bokemeyer et al., 2023) and high costs of pharmacotherapy (Bokemeyer et al., 2023; Lenzen-Schulte, 2018; Deutsches Aerzteblatt, 2022; IQWiG, 2023). This may contribute to the reason why smoking prevalence remains high and unchanged in adults (e.g., 29.7% in 2008–2011 based on German Health Interview and Examination Survey for Adults [DEGS1] (Lampert et al., 2013) and 28.2% in July 2024 based on the Deutsche Befragung zum Rauchverhalten [DEBRA] Study (DEBRA, 2024), and therefore reasonable that our findings (e.g., that a long and intense history of smoking increases the likelihood of persistent smoking) would most likely still be relevant today.

We found that high engagement in leisure time physical activity was associated with quitting smoking after a breast cancer diagnosis. Cancer survivors are recommended to be physically active for the numerous benefits that range from reducing fatigue, improving quality of life, and reducing treatment side effects (American Cancer Society, 2022), and for those who smoke cigarettes, physical activity can help relieve nicotine withdrawal symptoms and smoking cravings (Bock et al., 1999). Therefore, it is plausible that enhanced physical activity could serve as a preferred additional intervention for smoking cessation in women with breast cancer.

We acknowledge some potential limitations of our study. The information about health behaviors relied on self-report and thus there is a potential for recall bias. Furthermore, smoking behavior was self-reported without biochemical verification. This approach can introduce inaccuracies due to potential misreporting as participants may underreport or misrepresent their smoking behavior, either intentionally or unintentionally, particularly in contexts where there is pressure to quit or reduce smoking. Biochemical verification, such as cotinine testing, would provide a more accurate measure of smoking status (Benowitz et al., 2020) but was not utilized here due to resource constraints. Since not all eligible breast cancer survivors participated in the follow-up interview, selection bias may have occurred. We compared the characteristics between those who participated in follow-up (N = 450) and those who did not participate in follow-up (N = 178) and found no significant differences between the two groups in characteristics examined, with the exception of study region ($p < 0.001$).

Access, knowledge, or engagement in tobacco dependence treatment was not assessed in our study. Information on pharmacological aids (e.g., nicotine replacement therapy) or behavioral counseling would provide a clearer picture of factors contributing to quitting success or failure. In our study we were also unable to assess the impact of psychosocial factors on persistent smoking. Future research should focus on exploring psychosocial determinants of smoking behavior in cancer

survivors as these factors can significantly influence smoking cessation and maintenance. For example, psychological stress, mental health conditions such as depression and anxiety, and the level of social support all play critical roles in smoking behavior (Prochaska et al., 2017; Taylor et al., 2014). Stress can drive smoking as a coping mechanism, while mental health issues may complicate cessation efforts (Prochaska et al., 2017; Taylor et al., 2014). Additionally, robust social support can facilitate smoking cessation, however, more research is needed to understand how to effectively engage social support systems of patients with cancer (The Cancer Center Cessation Initiative Family and Social Support Systems Working Group). Addressing these psychosocial determinants is essential for developing effective, personalized smoking cessation interventions for cancer patients.

Additionally, more longitudinal studies with multiple follow-ups are needed to track smoking behavior over time following a cancer diagnosis. Since data was collected prior to the availability and popularity of emerging tobacco and nicotine products (i.e., e-cigarettes), future research should also focus on the use of nicotine and other tobacco products in patients with breast cancer. Examining how smoking patterns evolve in the short- and long-term, the impact of factors on smoking trajectories, and the effectiveness of various interventions can provide valuable insights for improving cessation strategies. While this study provides valuable insights into smoking behaviors among postmenopausal breast cancer survivors in Germany, its findings may have limited generalizability to other populations. The study's focus on an older, predominantly European cohort may not fully reflect smoking patterns and cessation challenges in younger women or in different cultural and healthcare contexts.

This study highlights the need for specialized smoking cessation programs for breast cancer survivors, especially those with a heavy smoking history. Standard cessation methods may be insufficient, making targeted interventions essential. Tobacco dependence treatment programs should consider the intensity of smoking and offer personalized support to address patient needs. Incorporating physical activity into cessation efforts could further enhance success rates. Exercise helps manage withdrawal symptoms, improve mood, and offer a healthy coping mechanism (Marcus et al., 1999; Mayo Clinic, 2024; U.S. Department of Health and Human Services, 2024). Combining smoking cessation with structured physical activity programs may lead to better long-term outcomes.

5. Conclusion

In this cohort of postmenopausal women with a history of breast cancer, we found that half of the breast cancer survivors who were actively smoking at baseline were still smoking at follow-up, an average of approximately 6 years later. The number of cigarettes smoked daily, duration of smoking, and leisure time physical activity were the most important determinants of persistent smoking after a breast cancer diagnosis. These findings indicate that targeted smoking cessation programs for breast cancer survivors should be promoted, especially for those with a more intensive smoking history. Furthermore, including physical activity in smoking cessation interventions may enhance cessation rates among breast cancer survivors and synergistically improve long-term clinical outcomes.

CRediT authorship contribution statement

Kathleen Gali: Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Sita Aryal:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Frederike Bokemeyer:** Writing – review & editing. **Sabine Behrens:** Writing – review & editing, Data curation. **Petra Seibold:** Writing – review & editing. **Nadia Obi:** Writing – review & editing, Project administration. **Heiko Becher:** Writing – review & editing, Project administration. **Jenny Chang-Claude:** Writing – review & editing, Supervision, Project administration.

Funding

The study was funded by the Deutsche Krebshilfe e.V. (#70–2892-BR I, #108253 and #108419) and by the German Cancer Research Center (DKFZ).This study was also funded by the German Federal Ministry of Education and Research (BMBF) and the Free and Hanseatic City of Hamburg as part of the Excellence Strategy of the German Federal and State Governments [Kathleen Gali].

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We are grateful to all MARIE study participants for their contribution and the interviewers who collected the data. We also thank Annika Möhl and Ursula Eilber for the most valuable technical assistance and data management.

Ethics statement.

The study was approved by the ethics committees of the University of Heidelberg, the Hamburg Medical Council, and the Medical Board of the state of Rhineland-Palatinate. All study participants provided written informed consent.

Availability of data and materials.

The data underlying this article will be shared on reasonable request to the corresponding author.

Data availability

Data will be made available on request.

References

Allen, A.M., Oncken, C., Hatsukami, D., 2014. Women and Smoking: The effect of gender on the epidemiology, health effects, and cessation of smoking. Curr Addict Rep. 1 (1), 53–60. https://doi.org/10.1007/s40429-013-0003-6.

Allen, A.M., Scheuermann, T.S., Nollen, N., Hatsukami, D., Ahluwalia, J.S., 2016. Gender differences in smoking behavior and dependence motives among daily and nondaily smokers. Nicotine Tob Res. 18 (6), 1408–1413. https://doi.org/10.1093/ntr/ntv138.

Alton, D., Eng, L., Lu, L., et al., 2018. Perceptions of continued smoking and smoking cessation among patients with cancer. J Oncol Pract. 14 (5), e269–e279. https://doi.org/10.1200/jop.17.00029.

American Cancer Society, 2022. Physical Activity and the Person with Cancer. https://www.cancer.org/content/dam/CRC/PDF/Public/9540.00.pdf (accessed 26 September 2023).

Benowitz, N.L., Bernert, J.T., Foulds, J., et al., 2020. Biochemical verification of tobacco use and abstinence: 2019 update. Nicotine Tob Res. 22 (7), 1086–1097. https://doi.org/10.1093/ntr/ntz132.

Bishop, J.D., Killelea, B.K., Chagpar, A.B., Horowitz, N.R., Lannin, D.R., 2014. Smoking and breast cancer recurrence after breast conservation therapy. Int J Breast Cancer. (2014), 327081. https://doi.org/10.1155/2014/327081.

Bock, B.C., Marcus, B.H., King, T.K., Borrelli, B., Roberts, M.R., 1999. Exercise effects on withdrawal and mood among women attempting smoking cessation. Addict Behav. 24 (3), 399–410. https://doi.org/10.1016/s0306-4603(98)00088-4.

Bokemeyer, F., Lebherz, L., Bokemeyer, C., et al., 2023. Practice patterns, experiences, and challenges of German oncology health care staff with smoking cessation in patients with cancer: a cross-sectional survey study. J Cancer Surviv. https://doi.org/10.1007/s11764-023-01501-2.

Bryant, J., Boyes, A.W., Hall, A., et al., Aug 2016. Prevalence and factors related to smoking and smoking cessation 6 months following a cancer diagnosis: a population-based study. J. Cancer Surviv. 10 (4), 645–653. https://doi.org/10.1007/s11764-015-0510-7.

Centers for Disease Control and Prevention, 2023. Smoking & Tobacco use: Benefits of Quitting. https://www.cdc.gov/tobacco/quit_smoking/how_to_quit/benefits/index.htm (accessed 4 January 2024).

Centers for Disease Control and Prevention, 2021. Smoking & Tobacco use: Clinical Interventions to Treat Tobacco Use and Dependence Among Adults. https://www.

cdc.gov/tobacco/patient-care/care-settings/clinical/index.html (accessed 7 December 2023).
Chaiton, M., Diemert, L., Cohen, J.E., et al., 2016. Estimating the number of quit attempts it takes to quit smoking successfully in a longitudinal cohort of smokers. BMJ open. 6 (6), e011045. https://doi.org/10.1136/bmjopen-2016-011045.
Chatzea, V.-E., Sifaki-Pistolla, D., Pistolla, G., et al., 2017. Smoking behaviour of lung and colorectal cancer patients during and after diagnosis. Which factors hinder smoking cessation? Tob Prev Cessat. 3 (May Supplement). https://doi.org/10.18332/tpc/70676.
Cox, L.S., Africano, N.L., Tercyak, K.P., Taylor, K.L., 2003.. Nicotine dependence treatment for patients with cancer. Cancer. 98 (3), 632–644. https://doi.org/10.1002/cncr.11538.
DEBRA: Deutsche Befragung zum Rauchverhalten, 2024. https://www.debra-study.info/about-debra (accessed 1 September 2024).
Del Riccio, M., Vettori, V., Raimondi, S., et al., 2023. The clinical impact of continued smoking in patients with breast and other hormone-dependent cancer: A systematic literature review. Crit Rev Oncol Hematol. 184, 103951. https://doi.org/10.1016/j.critrevonc.2023.103951.
Deutsches Aerzteblatt, 2022. G-BA begins consultations on medications for smoking cessation. https://www.aerzteblatt.de/nachrichten/132703/G-BA-nimmt-Beratungen-ueber-Arzneimittel-zur-Tabakentwoehnung-auf (accessed 7 January 2023).
Flesch-Janys, D., Slanger, T., Mutschelknauss, E., et al., 2008. Risk of different histological types of postmenopausal breast cancer by type and regimen of menopausal hormone therapy. Int J Cancer. 123 (4), 933–941. https://doi.org/10.1002/ijc.23655.
Gallaway, M.S., Glover-Kudon, R., Momin, B., et al., 2019. Smoking cessation attitudes and practices among cancer survivors - United States, 2015. J Cancer Surviv. 13 (1), 66–74. https://doi.org/10.1007/s11764-018-0728-2.
Gummerson, S.P., Lowe, J.T., Taylor, K.L., Lobo, T., Jensen, R.E., 2022. The characteristics of patients who quit smoking in the year following a cancer diagnosis. J Cancer Surviv. 16 (1), 111–118. https://doi.org/10.1007/s11764-021-01009-7.
Hall, S.M., Humfleet, G.L., Gorecki, J.A., et al., 2008. Older versus younger treatment-seeking smokers: differences in smoking behavior, drug and alcohol use, and psychosocial and physical functioning. Nicotine Tob Res. 10 (3), 463–470. https://doi.org/10.1080/14622200801901922.
IQWiG: Institute for Quality and Efficiency in Health Care, 2023. Benefit assessment of bupropion, cytisine, nicotine and varenicline for smoking cessation in severe tobacco dependence. https://www.iqwig.de/en/projects/a22-34.html (accessed 7 December 2023).
Joossens, L., Olefir, L., Feliu, A., Fernandez, E., 2022. The Tobacco Control Scale 2021 in Europe. http://www.tobaccocontrolscale.org/TCS2021.
Kim, Y., Lee, J.S., Cho, W.K., 2021. Factors Associated with Successful Smoking Cessation According to Age Group: Findings of an 11-Year Korea National Survey. Int J Environ Res Public Health. 18 (4). https://doi.org/10.3390/ijerph18041576.
Kim, H., Kim, M.-H., Park, Y.-S., Shin, J.Y., Song, Y.-M., 2015. Factors that predict persistent smoking of cancer survivors. J Korean Med Sci. 30 (7), 853–859. https://doi.org/10.3346/jkms.2015.30.7.853.
Koo, H.Y., Lee, K., Park, S.M., et al., 2020. Prevalence and Predictors of Sustained Smoking after a Cancer Diagnosis in Korean Men. Cancer Res Treat. 52 (1), 139–148. https://doi.org/10.4143/crt.2018.609.
Lampert, T., von der Lippe, E., Müters, S., 2013. Verbreitung des Rauchens in der Erwachsenenbevölkerung in Deutschland. Bundesgesundheitsbl 56, 802–808. https://doi.org/10.1007/s00103-013-1698-1.
Lenzen-Schulte, M., 2018. Tabakentwöhnung: Raucher schaffen es nicht allein. Dtsch Arztebl 115 (31–32), A-1436.
Malburg, C.M., Fucinari, J., Ruterbusch, J.J., et al., 2020. Continued smoking in African American cancer survivors: The Detroit Research on Cancer Survivors Cohort. Cancer Med. 9 (20), 7763–7771. https://doi.org/10.1002/cam4.3368.
Marcus, B.H., Albrecht, A.E., King, T.K., et al., 1999. The Efficacy of Exercise as an Aid for Smoking Cessation in Women: A Randomized Controlled Trial. Arch Intern Med. 159 (11), 1229–1234. https://doi.org/10.1001/archinte.159.11.1229.
Mayo Clinic, 2024. Healthy Lifestyle: Stress management. https://www.mayoclinic.org/healthy-lifestyle/stress-management/in-depth/exercise-and-stress/art-20044469 (accessed 15 September 2024).
Möhl, A., Orban, E., Jung, A.Y., et al., 2021. Comorbidity burden in long-term breast cancer survivors compared with a cohort of population-based controls from the MARIE study. Cancer. 127 (7), 1154–1160. https://doi.org/10.1002/cncr.33363.
Padubidri, A.N., Yetman, R., Browne, E., et al., 2001. Complications of postmastectomy breast reconstructions in smokers, ex-smokers, and nonsmokers. Plast Reconstr Surg. 107 (2). https://doi.org/10.1097/00006534-200102000-00007.
Park, E.R., Perez, G.K., Regan, S., et al., 2020. Effect of sustained smoking cessation counseling and provision of medication vs shorter-term counseling and medication advice on smoking abstinence in patients recently diagnosed with cancer: A randomized clinical trial. JAMA. 324 (14), 1406–1418. https://doi.org/10.1001/jama.2020.14581.
Passarelli, M.N., Newcomb, P.A., Hampton, J.M., et al., 2016. Cigarette smoking before and after breast cancer diagnosis: Mortality from breast cancer and smoking-related diseases. J Clin Oncol. 34 (12), 1315–1322. https://doi.org/10.1200/jco.2015.63.9328.
Paul, C.L., Tzelepis, F., Boyes, A.W., et al., 2019. Continued smoking after a cancer diagnosis: a longitudinal study of intentions and attempts to quit. J Cancer Surviv. 13 (5), 687–694. https://doi.org/10.1007/s11764-019-00787-5.
Pierce, J.P., Patterson, R.E., Senger, C.M., et al., 2014. Lifetime cigarette smoking and breast cancer prognosis in the After Breast Cancer Pooling Project. J Natl Cancer Inst 106 (1), djt359. https://doi.org/10.1093/jnci/djt359.
Prochaska, J.J., Das, S., Young-Wolff, K.C., 2017. Smoking, mental illness, and public health. Annu Rev Public Health. 38, 165–185. https://doi.org/10.1146/annurev-publhealth-031816-044618.
Robert Koch Institute, 2022. German Centre for Cancer Registry Data: Lung cancer. https://www.krebsdaten.de/Krebs/DE/Content/Krebsarten/Lungenkrebs/lungenkrebs_node.html (accessed 23 December 2023).
Robert Koch Institute, 2023. German Centre for Cancer Registry Data: Breast cancer. https://www.krebsdaten.de/Krebs/DE/Content/Krebsarten/Brustkrebs/brustkrebs_node.html (accessed 7 December 2023).
Schmidt, M.E., Steindorf, K., Mutschelknauss, E., et al., 2008. Physical activity and postmenopausal breast cancer: Effect modification by breast cancer subtypes and effective periods in life. Cancer Epidemiol Biomarkers Prev. 17 (12), 3402–3410. https://doi.org/10.1158/1055-9965.Epi-08-0479.
Schnoll, R.A., Martinez, E., Langer, C., Miyamoto, C., Leone, F., 2011. Predictors of smoking cessation among cancer patients enrolled in a smoking cessation program. Acta Oncologica. 50 (5), 678–684. https://doi.org/10.3109/0284186X.2011.572915.
Sheeran, P., Jones, K., Avishai, A., et al., 2019. What works in smoking cessation interventions for cancer survivors? A meta-analysis. Health Psychol. 38 (10), 855–865. https://doi.org/10.1037/hea0000757.
Swoboda, C.M., Walker, D.M., Huerta, T.R., 2019. Likelihood of Smoking Among Cancer Survivors: An Updated Health Information National Trends Survey Analysis. Nicotine Tob Res. 21 (12), 1636–1643. https://doi.org/10.1093/ntr/ntz007.
Taylor, G., McNeill, A., Girling, A., Farley, A., Lindson-Hawley, N., Aveyard, P., 2014. Change in mental health after smoking cessation: systematic review and meta-analysis. BMJ . 348, g1151. https://doi.org/10.1136/bmj.g1151.
The Cancer Center Cessation Initiative Family and Social Support Systems Working Group, 2021. Involving Family and Social Support Systems in Tobacco Cessation Treatment for Patients With Cancer. J Natl Compr Canc Netw. 19 (Suppl_1), S8–S11. https://doi.org/10.6004/jnccn.2021.7090.
Tseng, T.-S., Lin, H.-Y., Moody-Thomas, S., Martin, M., Chen, T., 2012. Who tended to continue smoking after cancer diagnosis: The national health and nutrition examination survey 1999–2008. BMC Public Health 12 (1), 784. https://doi.org/10.1186/1471-2458-12-784.
U.S. Department of Health and Human Services, 2020. Smoking cessation. A report of the surgeon general. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, Atlanta, GA.
U.S. Department of Health and Human Services, 2024. Fight Cravings with Exercise. https://smokefree.gov/challenges-when-quitting/cravings-triggers/fight-cravings-exercise (accessed 15 September 2024).
Van Heest, T., Rubin, N., Khariwala, S.S., 2022. Persistent tobacco use after treatment for head and neck cancer. JAMA Otolaryngol Head Neck Surg. 148 (7), 597–603. https://doi.org/10.1001/jamaoto.2022.0810.
Vrieling, A., Buck, K., Heinz, J., et al., 2012. Pre-diagnostic alcohol consumption and postmenopausal breast cancer survival: a prospective patient cohort study. Breast Cancer Res Treat. 136 (1), 195–207. https://doi.org/10.1007/s10549-012-2230-2.
Wang, K., Li, F., Zhang, X., Li, Z., Li, H., 2016. Smoking increases risks of all-cause and breast cancer specific mortality in breast cancer individuals: a dose-response meta-analysis of prospective cohort studies involving 39725 breast cancer cases. Oncotarget. 7 (50), 83134–83147. https://doi.org/10.18632/oncotarget.13366.
Westmaas, J.L., Alcaraz, K.I., Berg, C.J., Stein, K.D., 2014. Prevalence and correlates of smoking and cessation-related behavior among survivors of ten cancers: Findings from a nationwide survey nine years after diagnosis. Cancer Epidemiol Biomarkers Prev. 23 (9), 1783–1792. https://doi.org/10.1158/1055-9965.Epi-14-0046.
World Health Organization, 2023. Breast Cancer. https://www.who.int/news-room/fact-sheets/detail/breast-cancer (accessed 7 December 2023).