Association of engagement in cultural activities with cause-specific mortality determined through an eight-year follow up: The HUNT Study, Norway

Bente I. Løkken, Dafna Merom, Erik R. Sund, Steinar Krokstad, Vegar Rangul

1 Nord University, Levanger, Norway, 2 School of Health Science, Western Sydney University, Sydney, New South Wales, Australia, 3 HUNT Research Centre, Department of Public Health and Nursing, Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology (NTNU), Levanger, Norway, 4 Levanger Hospital, Nord-Trøndelags Hospital Trust, Levanger, Norway, 5 Norwegian Resource Centre for Arts and Health, Levanger, Norway

* bente.i.lokken@nord.no

Abstract

Participation in cultural activities may protect against cause-specific mortality; however, there is limited knowledge regarding this association. The present study examines the association between participation in a range of receptive and creative cultural activities and risk of cardiovascular disease- and cancer-related mortality. We also examined whether participation in such activities and influence by gender have on this association. We followed 35,902 participants of the Nord-Trøndelag Health Study (HUNT3) of Cardiovascular-Disease and Cancer Mortality from 2006–08 to 2016. Cox proportional-hazards regression was used to estimate the risk of specific mortality based on baseline cultural participation. During the eight-year follow-up, there were 563 cardiovascular-disease- and 752 cancer-related deaths among the sample (292,416 person years). Risk of cardiovascular-disease mortality was higher among non-participants in associations/club meetings (22%) and outdoor activities (23%), respectively, as well as non-attendees of art exhibitions (28%). People who engaged in music, singing, and theatre had a 27% reduced risk of cancer-related mortality when compared to non-participants. Among women, participating in associations/club meetings reduced the risk of cardiovascular-disease mortality by 36%. Men who participated in music, singing, and theatre had a 33% reduced risk of cancer mortality. Overall, a reduced risk of cardiovascular-disease mortality was associated with engaging in creative activities on weekly basis to less than twice per week. For both genders, participating in creative activities less than once a week reduced cardiovascular-disease mortality risk by 40% and 33%, respectively. For the overall sample, participating > 2 times per week in combined receptive and creative activities reduced cancer-related mortality by 29%. Participating frequently in both receptive and creative activities cultural activities was associated with lower risks of CVD and cancer-related mortality. Our data suggest that, to counteract the public health burden of cardiovascular disease- and cancer mortality...
Introduction

Non-communicable diseases (NCDs) contribute to approximately 40.5 million (71%) of all deaths globally [1], and to almost half of the disease burden in low- and middle-income countries [2]. Cardiovascular diseases (CVDs) and cancer are the leading causes of NCD-related deaths, accounting for 44% and 22%, respectively [1]. CVDs and cancer are complex and multi-causal, but lifestyle plays an important role in the prevention and management of these diseases. Consequently, preventive efforts have mainly encouraged smoking cessation, avoiding excessive alcohol intake, healthy eating, and leading a physically active lifestyle [1, 3].

Interest in the association between participation in cultural activities and health outcomes has increased in recent years. Cultural activities include everyday events performed for enjoyment, entertainment, recreation, or to contribute to society [4]. Such activities can provide opportunities for social and physical engagement [5] and, hence, may impact the population burden of major chronic diseases such as CVDs and cancer. A lack of social relationships is a strong predictor of premature mortality [6–8], is detrimental to cancer survival [6, 9], and can increase the risk of coronary heart disease and stroke by a degree similar to that found for other classic lifestyle risk factors [10]. Cultural profiles and consumption patterns vary significantly across social contexts [11]. Participation in cultural activities can be ‘passive’ or ‘active’ (i.e. ‘receptive’ or ‘creative’, respectively); passive participation includes being an attendee or spectator, while active participation includes actively engaging in creative activities by doing or performing. Creative cultural participation seems to be more common than receptive attendance [12]. However, there has been a lack of research regarding the effect cultural activities can have on population health and longevity.

Cultural activities can have health-enhancing therapeutic effects; however, most related studies have involved small sample sizes and were conducted in clinical contexts [13–15] (including research on patients with CVDs [16] and cancer [17–19]). This has limited the generalisability of the findings to the public health context [13, 20, 21]. Existing longitudinal evidence is characterised by fragmented approaches and a focus on the health benefits of specific activities; for example, dancing seems to reduce the risk of CVD-related mortality [22], and attending cultural events to reduce the risk of cancer-related mortality [23]. Epidemiological studies in this field have rarely examined a person’s cultural lifestyle as a whole in relation to investigating cause-specific mortality in the same sample [12, 14] and, to our knowledge, the association between receptive and creative cultural activities and cause-specific mortality has not been previously examined. Thus, evidence from population-based samples concerning the effects of participation in a wide-range of receptive and creative activities is important for establishing the public health significance of such activities. A Scandinavian study conducted by Väänänen et al. in 2009 explored the association between cultural engagement (arts and culture, activities in associations, societal action, reading literature, and studying) and all cause-and cause specific mortality, among full-time employees [24]. Intermediate and high engagements in such activities reduced the risk of CVD-related mortality but not cancer-related mortality. We are following up exploring this hypothesis in a total adult population cohort that is...
not limited to the workforce, with participation in cultural life measured by a range of recep-
tive and creative activities in a Norwegian setting.

Data from the Nord-Trøndelag Health Study (HUNT) can be linked to the Norwegian
Cause of Death Registry and affords the profiling of individuals’ cultural patterns in terms of
the risk of CVD- and cancer-related mortality. Using these data, the present study aimed to: 1)
identify the types of cultural activities that protect against CVD- and cancer-related mortality;
2) assess whether the number of receptive and creative activities a person engages in, including
weekly frequency of participation, are associated with CVD- and cancer-related mortality; and
3) explore possible gender differences between these three quantifiers (type, number, and
weekly frequency).

Materials and methods

Study population

HUNT is a longitudinal population health study that comprised four cross-sectional surveys.
Participation in the surveys was voluntary. The present study uses data from the third HUNT
survey (HUNT3, 2006–2008), in which all residents of the north part of Trøndelag County
(n = 93,860) who were aged ≥ 20 years were invited to participate; in total, 50,807 (response
rate = 54.1%) participated [25]. Participants were given a self-report questionnaire (Q1; mailed
with the invitation to participate) and were invited to a clinical examination. Q1 included
questions concerning participants’ socio-demographic characteristics, health behaviours and
diseases (both physical and mental), and social relationships. At the clinical examination, a sec-
ond questionnaire (Q2), which concerned cultural activities [26], was distributed with a pre-
paid envelope; this was to be completed at home and returned by mail. Overall, 41,198 partici-
pants (response rate = 81%) returned Q2; of these, 2.4% (984) did not answer any of the ques-
tions concerning receptive or creative activities and were excluded, meaning our baseline
sample comprised 40,214 participants.

The participants signed written consent forms, which included approval to link their infor-
mation to national registers [27]. This study was approved by the Regional Committees for
Medical Research and Health Research Ethics in Norway (ref. no.: 2016/282/REK midt).

Cultural participation

Cultural participation was assessed using two validated questions concerning receptive and
creative activities, respectively. These questions were proven to be sufficient for public health
research [28].

The receptive activity question was ‘How often in the last six months have you attended: 1)
a museum/art exhibition; 2) a concert, theatre, or film; 3) a church/chapel; 4) a sports event?’
The response options were: ‘more than three times a month’, ‘1–3 times a month’, ‘1–6 times
in the last six months’, and ‘never’. We dichotomised the responses into ‘never’ and ‘ever’.
Then, for each participant, we summarised all of activities he/she reported attending, which
reflected the diversity of their engagement. Summing the scores across all receptive activities
produced a range from 4 (attending all receptive activities) to 0 (answering ‘never’ to all). Few
participants reported attending more than three activities; thus, we created the category ‘3–4
activities’. Next, a score representing weekly frequency of participation in the receptive activi-
ties was assigned by giving each response option a weekly score: ‘more than three times a
month’ received a score of 1 (i.e. approximately once a week), ‘1–3 times a month’ was scored
0.5, ‘1–6 times in the last six months’ was scored 0.25, and ‘never’ was scored zero. After sum-
mimg the scores across all receptive activities, we used quartiles to reflect weekly engagement:
the lowest quartile represented ‘never to seldom’ (score: 0–0.25), the second quartile
represented ‘every other week or less than once per week’ (0.5–0.99), the third quartile represented ‘once to less than twice per week’ (1–1.99), and the highest quartile represented ‘2–4 times per week’ (2–4).

Engagement in creative activities was measured using the question: ‘How often in the last six months have you participated in: 1) an association or club meeting/activity, 2) music, singing, or theatre, 3) parish work, 4) outdoor activities, 5) dancing, 6) sports or exercise?’ For this research, participation in ‘sports or exercise’ was excluded because exercise is a subtype of physical activity (PA), which was assessed as a covariate in Q1. The response options were: ‘more than once a week’, ‘once a week’, ‘1–3 times a month’, ‘1–5 times in the last six months’, and ‘never.’ As above, we dichotomised these categories into ‘never’ and ‘ever’. Then, for assessing diversity of participation in creative activities we summarised, for each participant, the number of activities he/she reported engaging in, ranging from 5 (participation in all creative activities) to 0 (never). We created three categories overall by merging those who performed 3–5 activities into a single category. Next, an index reflecting weekly participation was created by giving each response option a score: ‘more than once a week’ and ‘once a week’ received a score of 1; ‘1–3 times a month’ was scored 0.5, ‘1–5 times in the last six months’ was scored 0.25, and ‘never’ was scored zero. The sum of the scores across all creative activities was divided into quartiles: the lowest quartile represented ‘never to seldom’ (0–0.25), the second quartile represented ‘every other week or less than once per week’ (0.5–0.99), the third quartile represented ‘once to less than twice per week’ (1–1.99), and the highest quartile represented ‘2–5 times per week’ (2–5).

Finally, we examined the total number of activities each participant engaged in during the past six months, combining all types of receptive and creative activities. The highest score was 9 (participation in all four receptive and five creative activities), and the lowest was 0 (never). We created seven categories by merging those who performed 7–9 activities into a single category. Similarly, combined weekly participation was created by summing weekly participation in each activity and dividing it into quartiles: the lowest quartile represented ‘never to seldom’ (0–0.25), the second quartile represented ‘every other week or less than once per week’ (0.5–0.99), the third quartile represented ‘once to less than twice per week’ (1–1.99), and the highest quartile represented ‘2–9 times per week’ (2–9).

Participants who did not respond to any of the receptive and creative activity questions were considered to have provided missing data for the cultural participation module (n = 984), and were excluded. Participants who provided only one response across the receptive and creative activity questions were not considered to have provided missing data, under the assumption that they only provided answers if they participated in the specific activity, given it was a self-completed questionnaire. This resulted in 1,228 and 1,347 participants being recorded as never participating in any receptive activity and any creative activity, respectively. As a result, our descriptive analysis of the sample included 40,214 participants.

Mortality

The study data were linked to the Norwegian Cause of Death Registry. These mortality data are based on death certificates reported by doctors, who are required to report the cause of death in accordance with the International Classification of Diseases (ICD-10). Both the degree of coverage and completeness are high, with medical information available for over 98% of all deaths [29]. For the present research, the cause-specific outcomes were CVD- and cancer-related deaths, for which the ICD-10 codes are ‘I00-99’ and ‘C00-97’, respectively.
Covariates

The following socio-demographic characteristics were considered confounders: age, gender, marital status, and socioeconomic status (SES) determined based on occupation. Age was categorised into 10-year categories, beginning at 20–29 years and ending at 80+ years. Ten occupation types, listed based on the ISCO88 classification [30], were collapsed into three categories: low (‘elementary occupations’), medium (‘clerks’, ‘service workers and ship and market sales workers’, ‘skilled agriculture and fishery workers’, ‘craft and related trades workers’ and ‘plant and machine operators and assemblers’), and high level (‘legislators, senior officials, and managers’, ‘professionals’, ‘technicians and associate professionals’, and ‘armed forces and unspecified’). Of the participants who provided missing information regarding occupation, 1,442 (4.0%) were categorised as having elementary occupations because the data showed they were young (possibly students and not working) or old (likely retired). Marital status, which featured nine response options, was dichotomised into ‘being in a relationship’ (married, registered partner) or ‘other’ (unmarried, widow(er), divorced, separated, separated partner, divorced partner, and surviving partner). Health-related confounders comprised longstanding illness and a range of health behaviours. Q1 included one question concerning having a longstanding illness: ‘do you suffer from longstanding (at least one year) illness or injury of a physical or psychological nature that impairs your functioning in daily life?’ (response: ‘yes’ or ‘no’). Smoking status was reported as ‘never’, ‘former’, or ‘daily’. Alcohol consumption (number of units of beer, wine, and spirits consumed in the seven days preceding the survey) was calculated and categorised into ‘never’ (0 units/week), low (1–6 units/week), and high (≥ 7 units/week). For PA, we calculated metabolic equivalents (METs), which reflected activity level in min per week, based on frequency, duration, and intensity. This was divided into two levels: above and below the international recommendation of at least 150 min/week of moderate-to-vigorous intensity, respectively [31]; this corresponds to 500 MET minutes per week. A continuous body mass index (BMI) variable was constructed based on the height and weight variables measured in the clinical examination; participants were categorised into three groups: ‘normal weight’ (< 18–24.9), ‘overweight’ (25.0–29.9), or ‘obese’ (≥ 30).

Statistical analysis

First, we cross-tabulated our primary exposures (cultural activity) with likely confounding factors for each gender. The relationships between cultural participation and cause-specific mortality were analysed using multivariable time to event models. The Cox proportional hazard regression model was applied, and hazard ratios (HRs) and 99% confidence intervals (CIs) were reported. These HRs represented the ratios between various groups regarding the probability of dying from CVD and cancer, respectively. Proportional hazard assumptions were tested. Based on the large number of hypothesis tests performed, 99% CIs were used to reduce the probability for type-1 error rate. We developed estimates for each receptive and creative activity. We also examined the effect of diversity of participation (based on the number of different activities participants engaged in) and level of participation (measured using weekly frequency). These explanatory quantifiers were explored within each mode of cultural activity (i.e. receptive and creative), and also for all cultural activities combined. Models with missing category on the covariates were also specified, and finally, we fitted models in which we removed participants who died within the first two years (to circumvent problems regarding reverse causation). Hence the association between cultural participation and cause-specific mortality included comprised 35,902 individuals, as 9.9% (3,996) provided missing data for any covariates and 0.87% (316) died from all-cause mortality.
Causal directed acyclic graphs were used to guide the modelling strategy. First, models were run with each cultural activity only, adjusting for age and gender. Second, SES and marital status were added to the model, and the third model included longstanding illness. In the final model, lifestyle covariates were added (alcohol consumption, smoking status, PA, BMI). In addition, gender-specific analyses were performed for all of these models. Person-time was determined for each participant based on the period from the date of baseline participation to date of death, of loss to follow up, or December 31st, 2015, whichever came first. IBM SPSS version 24 (SPSS, inc., Chicago, Illinois) was used to perform the analyses.

Results

Descriptive analyses

Overall, data for 17,606 (43.8%) men and 22,608 (56.2%) women (mean age: 55 and 53 years, respectively) were included in the descriptive analyses. Table 1 shows the gender-specific distribution of the participants in terms of the covariates (first column), and among those who performed each receptive cultural activity. Strong gender differences were observed for occupational class, marital status, alcohol use, and BMI. Regarding activities, notable gender differences were observed for attending places of worship (church/chapel) and concert/theatre/film. Women with low-level occupations tended to participate in these activities more than men with low-level occupations; similarly, married women tended to visit places of worship more than married men (67% vs. 28%). Never using alcohol and having normal BMI were more prevalent among women than men across all receptive activities, whereas gender differences regarding smoking status and longstanding illness were small across each receptive activity.

Table 2 shows gender-specific distribution of participation in each creative activity in terms of each covariate. For each creative activity, there was a higher representation of women with low-level occupations than men with low-level occupations. Strong gender differences regarding marital status were observed for participation in ‘parish work’ and ‘dance’, with more married men than married women engaging in these activities. Gender differences regarding alcohol, smoking, and BMI were noted across all activities, with more women than men never drinking alcohol, never smoking, and being of normal weight.

Association with cause-specific mortality

The mean duration of follow-up was 8.15 years, resulting in a total of 292,416 person years. During this time, 235 (1.04%) women and 328 (1.86%) men died from CVD-related issues, and 313 (1.38%) women and 439 (2.49%) men died from cancer-related issues (Table 3).

Individual activities

The relationships between each cultural activity and the respective dependent variables of CVD- and cancer-related mortality were examined individually (Table 3). The results of the fully adjusted multivariable analysis revealed that, among receptive activities, only attending museum/art exhibitions positively influenced CVD-related mortality; the fully adjusted model showed a significantly lower risk (HR: 0.72; 99% CI: 0.53–0.97) for the whole population in this regard. Gender-specific analyses revealed that neither women nor men experienced a significant effect of participating in any of the receptive activities.

Several creative activities lowered the risk of CVD-related mortality; association or club meetings/activities reduced CVD-related mortality by 22% (adjusted HR: 0.78; 99% CI: 0.62–0.99), and outdoor activities produced a reduction of 23% (adjusted HR: 0.77; 99% CI: 0.61–0.98). Gender-specific analysis revealed that the only activity that lowered the risk of CVD-
related mortality in women was participating in association or club meetings/activities (risk reduction: 36%; adjusted HR: 0.64; 99% CI: 0.45–0.92). In contrast, no creative activities were found to reduce CVD-related mortality among men.

Only music, singing, and theatre was found to significantly influence cancer-related mortality (risk reduction: 27%; adjusted HR: 0.73; 99% CI: 0.56–0.97). However, gender-specific analysis showed that the protective effect of music, singing and theatre was not present for women but was strong for men, at 33% (adjusted HR: 0.67; 99% CI 0.47–0.96).

Diversity of participation

Diversity in participation was not found to be an important determinant of CVD- or cancer-related mortality for either men or for women (S1–S6 Figs). In the fully adjusted model CVD-related mortality among those who participated in two, three or more receptive or creative activities did not significantly differ when compared to those who participated in less than two activities. A similar pattern was found in gender-specific analysis, which suggested that engaging in several different activities did not produce any extra benefits regarding CVD-related mortality. In contrast, the total number of receptive and creative activities engaged in impacted cancer-related mortality, and gender-specific analyses revealed that this influenced men’s longevity (S6 Fig). Notably, participating in increasing numbers of receptive activities did not seem to moderate a reduction in risk of CVD- or cancer-related mortality (see S3 and S4 Figs).

Table 1. Gender-specific distribution (%) of the participants in terms of the covariates and participation in each receptive cultural activity (n = 40,214). The HUNT Study (2006–08).

| Activity Type          | All       | Museum/art exhibition | Concert, theatre, film | Church/chapel | Sports event |
|------------------------|-----------|------------------------|------------------------|---------------|--------------|
|                        | Men       | Women                  | Men                    | Women         | Men          | Women       |
| Total                  | 17,606 (43.8) | 22,608 (56.2) | 4,913 (27.9)  | 7,210 (31.9)  | 10,008 (56.8) | 14,591 (64.5) | 9,581 (54.4) | 12,957 (57.3) | 9,182 (52.2) | 9,165 (40.5) |
| Mean age ± std.        | 55.2 ± 15.0 | 53.5 ± 16.1 | 54.8 ± 14.1 | 52.2 ± 14.6 | 51.6 ± 14.8 | 49.5 ± 15.1 | 56.5 ± 14.4 | 54.4 ± 15.9 | 51.9 ± 14.3 | 46.9 ± 14.1 |
| Occupation level       |           |                        |                        |               |              |              |              |              |              |              |
| Low                    | 4.7       | 15.5                   | 4.7                    | 7.9           | 4.7          | 10.5         | 3.9          | 14.0          | 4.7          | 9.5          |
| Medium                 | 60.0      | 51.7                   | 40.3                   | 40.2          | 50.8         | 47.5         | 58.6         | 51.4          | 54.4         | 48.2         |
| High                   | 35.4      | 32.8                   | 55.0                   | 51.9          | 44.5         | 42.0         | 37.5         | 34.6          | 40.8         | 42.3         |
| Marital status         |           |                        |                        |               |              |              |              |              |              |              |
| Married†               | 64.8      | 57.6                   | 69.0                   | 61.7          | 64.6         | 58.5         | 29.4         | 61.8          | 65.0         | 59.8         |
| Other                  | 35.2      | 42.4                   | 31.0                   | 38.3          | 35.4         | 41.5         | 70.6         | 48.2          | 35.0         | 40.2         |
| LLI                    |           |                        |                        |               |              |              |              |              |              |              |
| Yes                    | 41.4      | 41.9                   | 35.3                   | 36.4          | 34.1         | 35.5         | 41.0         | 41.5          | 34.7         | 31.4         |
| No                     | 58.6      | 58.1                   | 64.7                   | 63.6          | 65.9         | 64.5         | 59.0         | 58.5          | 65.3         | 68.6         |
| Alcohol, units/week    |           |                        |                        |               |              |              |              |              |              |              |
| Never                  | 15.1      | 27.9                   | 11.3                   | 18.6          | 10.4         | 20.7         | 16.4         | 29.6          | 10.5         | 20.2         |
| 0.5–6.5                | 74.9      | 69.2                   | 75.9                   | 77.2          | 78.1         | 76.0         | 75.6         | 68.0          | 79.3         | 77.1         |
| ≥ 7                    | 10.0      | 2.9                    | 12.8                   | 4.2           | 11.5         | 3.3          | 8.1          | 2.5           | 10.2         | 2.7          |
| Cigarette smoking      |           |                        |                        |               |              |              |              |              |              |              |
| Never                  | 40.1      | 45.2                   | 45.1                   | 48.7          | 45.9         | 47.0         | 43.2         | 49.9          | 46.6         | 48.2         |
| Former                 | 38.1      | 30.4                   | 38.0                   | 32.7          | 34.6         | 31.1         | 38.5         | 29.6          | 33.8         | 28.7         |
| Daily                  | 21.8      | 24.4                   | 16.9                   | 18.7          | 19.5         | 21.9         | 18.3         | 20.5          | 19.5         | 23.1         |
| Physical activity, MET |           |                        |                        |               |              |              |              |              |              |              |
| < 2.5                  | 60.2      | 56.4                   | 53.9                   | 49.8          | 55.9         | 51.2         | 59.0         | 56.4          | 52.9         | 47.6         |
| ≥ 2.5                  | 39.8      | 43.6                   | 46.1                   | 50.2          | 44.1         | 48.8         | 41.0         | 43.6          | 47.1         | 52.4         |
| BMI                    |           |                        |                        |               |              |              |              |              |              |              |
| Normal                 | 24.6      | 38.4                   | 25.4                   | 42.5          | 25.4         | 41.4         | 23.8         | 36.6          | 25.1         | 43.6         |
| Overweight             | 53.1      | 38.1                   | 53.5                   | 37.5          | 53.9         | 37.6         | 54.1         | 39.5          | 53.9         | 36.6         |
| Obesity                | 22.4      | 23.5                   | 21.0                   | 20.0          | 20.6         | 21.1         | 22.2         | 23.9          | 21.0         | 19.8         |

†Marriage/relationship
MET: metabolic equivalent; LLI: Limiting longstanding illness.

https://doi.org/10.1371/journal.pone.0248332.t001
The differences appeared between participants who participated in one activity and those who did not participate at all.

**Weekly frequency of participation**

Table 4 shows the results of the fully adjusted models presenting the association between weekly frequency of participation and CVD- and cancer-related mortality for all activities combined, as well as for receptive and creative activities, respectively. Weekly participation in creative activities significantly reduced the risk of CVD-related mortality; those participating every other week or less than once per week and those participating once to less than twice per week had a 36% (HR: 0.64; 99% CI: 0.46–0.89) and 26% (HR: 0.74; 99% CI: 0.57–0.96), respectively, lower risk of CVD-related death. Participating more than twice a week in any of the creative activities was not associated with a significantly lower risk of CVD-related mortality.

While gender-specific analyses indicated similar trends for both genders in terms of risk reduction, statistical significance was found only among men who participated in creative activities every other week or less than once per week (40%; HR: 0.60; 99% CI: 0.39–0.93).

In contrast, for cancer-related mortality significant reductions, after full adjustment, were observed when weekly frequency of participation in combined activities was more than twice a week. In other words, when creative and receptive activities were combined, a significantly lower HR of cancer-related mortality was found (HR: 0.71; 99% CI: 0.53–0.97).

---

**Table 2. Gender-specific distribution (%) of participants in terms of engagement in each creative cultural activity (n = 40,214).** The HUNT Study (2006–08).

| Association or club meeting/activity | Men | Women | Men | Women | Men | Women | Men | Women | Men | Women |
|-------------------------------------|-----|-------|-----|-------|-----|-------|-----|-------|-----|-------|
| Total                               | 7,136 (40.5) | 9,373 (41.5) | 3,364 (19.1) | 4,404 (19.5) | 802 (4.6) | 1,410 (6.2) | 14,426 (81.9) | 16,999 (75.2) | 5,683 (32.3) | 8,443 (37.3) |
| Mean age ± std.                     | 53.9 ± 13.8 | 54.5 ± 15.3 | 54.4 ± 15.2 | 49.8 ± 16.0 | 56.6 ± 14.8 | 57.0 ± 15.5 | 54.1 ± 14.4 | 51.1 ± 14.8 | 54.9 ± 13.3 | 50.2 ± 14.2 |
| Occupation level                    | Low | 3.7 | 10.9 | 4.7 | 9.7 | 4.5 | 13.7 | 4.5 | 11.4 | 4.3 | 10.7 |
| Medium                              | 50.0 | 48.2 | 49.9 | 45.0 | 51.0 | 44.5 | 56.9 | 50.0 | 54.7 | 50.5 |
| High                                | 46.3 | 40.9 | 45.3 | 45.3 | 44.5 | 41.8 | 38.7 | 38.6 | 41.0 | 38.9 |
| Marital status                      | Marriage | 69.5 | 63.0 | 67.3 | 57.7 | 78.9 | 68.3 | 65.5 | 60.2 | 67.3 | 59.8 |
| Other                               | 30.5 | 37.0 | 32.7 | 42.3 | 21.1 | 31.7 | 34.5 | 39.8 | 32.7 | 40.2 |
| LLI                                 | Yes | 36.7 | 39.5 | 38.9 | 36.3 | 39.8 | 44.8 | 38.3 | 37.0 | 36.4 | 34.9 |
| No                                  | 63.3 | 60.5 | 61.1 | 63.7 | 60.2 | 55.2 | 61.7 | 63.0 | 63.6 | 65.1 |
| Alcohol, units/week                 | Never | 12.7 | 25.8 | 14.2 | 24.2 | 46.3 | 55.4 | 13.0 | 23.1 | 7.4 | 16.7 |
|                                      | 0.5–6.5 | 77.1 | 71.5 | 75.0 | 72.9 | 50.2 | 43.3 | 76.6 | 73.7 | 81.7 | 79.7 |
|                                      | ≥ 7 | 10.2 | 2.7 | 10.8 | 3.0 | 3.5 | 1.3 | 10.4 | 3.2 | 10.9 | 3.6 |
| Cigarette smoking                   | Never | 46.8 | 50.3 | 42.9 | 50.7 | 54.2 | 66.3 | 42.5 | 45.6 | 43.5 | 44.8 |
|                                      | Former | 34.7 | 9.8 | 36.7 | 28.1 | 30.3 | 22.6 | 36.9 | 30.9 | 36.4 | 30.4 |
|                                      | Daily | 18.5 | 19.8 | 20.5 | 21.3 | 15.5 | 11.1 | 20.7 | 23.5 | 20.1 | 24.9 |
| Physical activity, MET              | < 2.5 | 57.8 | 54.9 | 57.6 | 52.0 | 61.7 | 62.2 | 56.7 | 50.5 | 55.8 | 48.1 |
|                                      | ≥ 2.5 | 43.1 | 45.1 | 42.4 | 48.0 | 38.3 | 37.8 | 43.3 | 49.5 | 44.2 | 51.9 |
| BMI                                 | Normal | 23.7 | 36.7 | 24.8 | 40.2 | 25.2 | 35.6 | 24.7 | 40.9 | 23.5 | 42.0 |
|                                      | Overweight | 53.8 | 39.0 | 53.8 | 36.9 | 51.1 | 37.7 | 54.0 | 38.2 | 55.0 | 38.5 |
|                                      | Obesity | 22.5 | 24.3 | 21.4 | 22.9 | 23.8 | 26.7 | 21.3 | 20.8 | 21.5 | 19.5 |

1Marriage/relationship

MET: metabolic equivalent; LLI: Limiting longstanding illness

https://doi.org/10.1371/journal.pone.0248332.t002
Discussion

The results of this observational cohort study suggest that participation in cultural life is associated with a reduced risk of CVD-related death. In particular, our results indicate that frequent weekly participation in creative activities reduces the risk of CVD- and cancer-related mortality. When receptive and creative activities were combined, a significantly lower HR for cancer-related mortality was found for the sample (both genders included), but only if the frequency of participation was over twice a week; this is probably attributable to creative activity participation. Further, our results indicated that diversity of participation does not influence this association.

Before discussing our findings in the context of other studies, it is important to note that methodological differences between studies, such as the types of cultural activities examined, the operationalisation of the exposure measures (i.e. measuring individual activities or frequency or diversity of participation), and the outcomes measured, greatly impact inter-study comparisons. Another important issue is the difficulty separating the total number of activities from the frequency of participation, as it is likely that, the more activities a person performs, the higher his/her frequency score. These two quantifiers of the diversity and frequency of cultural-activity engagement are not mutually exclusive and have seldom been implemented in other studies. We observed that in previous published articles, the most common method was to combine the number of activities and frequency in the same index.

### Table 3. Total and gender-specific associations (based on adjusted hazard ratios and 99\% confidence intervals) between participation in one or more receptive/creative cultural activities and cardiovascular-disease- and cancer-related mortality (n = 35,902). The HUNT Study (2006–08).

| Activities | Deaths/person years | HR (99\% CI) | HR (99\% CI) |
|------------|---------------------|--------------|--------------|
|            | Museum/art exhibition | Concert, theatre, film | Church/chapel | Sports event | Association or club meeting/activity | Music, singing, theatre | Parish work | Outdoor activities | Dance |
| Participants | 11,305 | 22,870 | 20,232 | 17,082 | 15,143 | 7,167 | 1,970 | 28,910 | 13,083 |
| CVD All | 563/292416 | 0.72 | 0.85 | 1.00 | 0.83 | 0.78 | 1.07 | 0.91 | 0.77 | 0.82 |
| Men | 328/129851 | 0.74 | 0.75 | 0.97 | 0.75 | 0.90 | 1.04 | 1.40 | 0.74 | 0.79 |
| Woman | 235/162565 | 0.71 | 1.04 | 1.02 | 1.06 | 0.64 | 1.10 | 0.53 | 0.83 | 0.83 |
| Cancer All | 752/292416 | 0.98 | 0.90 | 0.85 | 0.95 | 0.88 | 0.73 | 0.72 | 0.82 | 0.84 |
| Men | 439/129851 | 0.83 | 0.84 | 0.84 | 0.95 | 0.91 | 0.67 | 0.73 | 0.87 | 0.76 |
| Woman | 313/162565 | 1.18 | 0.98 | 0.86 | 0.93 | 0.86 | 0.83 | 0.71 | 0.74 | 0.96 |

† Adjusted for: age and gender, occupation and marital status, limiting longstanding illness, and behavioural lifestyle factors (smoking, alcohol consumption, physical activity, and body mass index; ref.: never).

CI: confidence interval; CVD: cardiovascular disease; HR: hazard ratio

[https://doi.org/10.1371/journal.pone.0248332.t003](https://doi.org/10.1371/journal.pone.0248332.t003)
A previous Scandinavia-based prospective study examined similar outcomes to the present research, and used an index that combined frequency of participation in receptive activities (attending a cinema, theatre, art gallery, museum, and live music) and the number of these activities attended. The study found that those who live in urban areas and rarely attend cultural events have a threefold higher risk of cancer-related mortality when compared to frequent attendees [23]. In contrast, we did not find an association between reduced cancer-related mortality and frequent attendance of receptive activities, unless creative activities were also performed. Contrary to our finding, Fancourt et al. studied the association between all-cause mortality among adults aged 50 years and above and found that those who engaged with receptive arts activities even on an infrequent basis such as every few months or more had 31% lower mortality rate compared to those who never engaged in such activities. This finding was independent of demographic, SES, health related behaviour and social factor and after adjustment for their cognitive status, mental health and PA [32].

In our cohort, participation in outdoor activities and club meetings was strongly associated with CVD-related mortality, while parish work, singing or playing music, and dancing were not. Vääännen et al. [24] studied, among a cohort of Finnish industrial employees (n = 7,922), the association between engagement in cultural activities (arts and culture, association activities, societal actions, reading literature, and studying) and main causes of mortality. High engagement (i.e. approximately twice a month to daily) was associated with a 32% lower risk of CVD-related mortality. There are several differences between these findings and those of the present study. The creative activities examined by Vääännen et al. differed from those measured in HUNT3; we found a reduced risk of CVD-related mortality among those who participated in creative activities as infrequently as less than once a week; and Vääännen et al. did not find any associations with cancer-related mortality [24].

### Table 4. Association, both overall and gender-specific, between CVD- and cancer-related mortality, respectively, and weekly frequency of participation in receptive, creative, and combined activities (based on adjusted† hazard ratios and 99% confidence intervals: N = 35,902). The HUNT Study (2006–08).

| Frequency/wk. | CVD | Cancer |
|--------------|-----|--------|
|               | Combined | Receptive | Creative |
|               | All | Men | Women | All | Men | Women | All | Men | Women |
| 0.5–<1 | 0.92 (0.66–1.29) | 1.03 (0.65–1.63) | 0.79 (0.48–1.29) | 0.82 (0.63–1.07) | 0.77 (0.54–1.09) | 0.88 (0.59–1.31) | 0.64 (0.46–0.89) | 0.60 (0.39–0.93) | 0.67 (0.41–1.09) |
| 1–<2 | 0.71 (0.55–1.01) | 0.78 (0.51–1.19) | 0.68 (0.43–1.07) | 0.92 (0.69–1.22) | 0.84 (0.58–1.22) | 1.05 (0.67–1.65) | 0.74 (0.57–0.96) | 0.77 (0.55–1.08) | 0.68 (0.45–1.03) |
| ≥ 2* | 0.72 (0.52–1.01) | 0.76 (0.48–1.19) | 0.67 (0.41–1.11) | 0.85 (0.33–2.15) | 0.69 (0.18–2.56) | 1.43 (0.38–5.32) | 0.90 (0.56–1.44) | 0.80 (0.43–1.51) | 0.96 (0.47–1.96) |

† Respective frequency max: four times/wk; creative frequency max: five times/wk; combined frequency max: nine times/wk.

Fully adjusted ref.: never or seldom.

https://doi.org/10.1371/journal.pone.0248332.t004
Also contrasting with our results, Merom et al. [22] found dancing to be inversely associated with CVD-related mortality. Specifically, they found moderate-intensity dancing to be associated with a lower risk of CVD-related mortality to a greater extent than moderate-intensity walking (46% versus 33%, respectively). Outdoor activity is positively related to PA, which is an established protective factor against mortality from CVD and from some types of cancer. Donneyong et al. [33] found that outdoor activity is strongly associated with a reduced risk of CVD-related mortality (30–47%, depending on participation frequency), and later reported a risk reduction of 28% independent of total PA [34]. These results are stronger than those obtained for our cohort, which showed that outdoor-activity participation produces a risk reduction of 23%. Outdoor activities may be a marker of an active lifestyle, and reduced sedentary behaviour. However, engagement in such activities does not necessarily involve PA, and outdoor activity is significantly different from exercise. Engagement in outdoor activity influences levels of inactivity and sedentarism, both of which are contributors to chronic diseases [35, 36].

The joint association between PA and sedentary behaviour has been intensively explored in the past decade [37]. Rangul et al. [38] found no evidence that people who spend prolonged periods seated or who have low levels of PA have an increased risk of total cancer incidence when compared to people who spend short periods seated or who are physically active. Autenrieth et al. [39] found that PA during leisure time is associated with cancer-related mortality, and vigorous activity with CVD-related mortality. In contrast, a systematic review found significant associations between sedentary behaviour and cancer [40]. Sedentary behaviour and physical inactivity are associated with a risk of several chronic diseases [41–43], and are of importance in regard to incident CVD [44] and cancer, especially colon and breast cancer [41]. Stamatakis, E et.al. revealed that by replacing one hour sedentary time with walking, led to a 14% reduced risk of all-cause mortality [45]. Another explanation for the strong association between outdoor activity and reduced CVD risk is that outdoor activity involves exposure to natural environments and provides opportunities for positive restoration [46]. The level of energy expenditure associated with outdoor activities can vary; in the present study, we adjusted for energy expenditure, but an attributable effect on CVD risk remained. Another possible explanation is that outdoor activities increase sunlight exposure, which can prevent autoimmune diseases, CVD, and cancers [47]. Sunlight exposure counteracts vitamin-D deficiency, which is associated with increased risk of CVD [47], deadly cancers [47, 48], and non-melanoma skin cancer [47]. However, Donneyoung et al. found CVD-related mortality risk to be independent of vitamin-D level [33, 34].

Among receptive activities, only attending museum and art exhibitions appeared to protect against CVD-related mortality, but none protected against cancer-related mortality. To our knowledge, museum visits has not been previously explored as an activity related to mortality; but instead, it has been considered in relation to general health and wellbeing [49–52] or cognitive decline and the prevention of dementia. A longitudinal study by Fancourt et al. [49] found that visiting a museum every few months is related to lower incidence of dementia in adults aged > 50 years. A possible explanation is that visiting museums reduces the negative effect of possible sedentary behaviours and isolation, and can also represent social engagement [49]. In general, a lack of social support is known to cause negative psychological states, such as anxiety and depression, which further can increase the risk of CVD [53]. A previous study performed a tactile experiment in which participants handled and discussed a selection of museum objects and discussed photographs of the same objects; this activity enhanced cancer patients’ well-being, positive emotions, and happiness [54]. However, we found no association between attending museums or art exhibitions and cancer-related mortality.

Music, singing, and theatre engagement was the only creative activity that was significantly associated with a reduced risk of cancer-related mortality. This findings is supported by many
clinical studies that have shown such activity to have a therapeutic effect on cancer patients. Music has been linked to immune response [13, 55, 56], with stress reduction as a possible pathway, and may impact individuals’ neurological and immunological systems [56]. However, there is a lack of epidemiological studies in this regard. Our results, therefore, the first to show that music, singing, and theatre participation reduces the risk of cancer-related mortality by 27% in the general population; this should have implications for future research.

There is a strong empirical rationale for our exploring of gender differences. First, patterns and durations of diseases can differ across genders [57]. Second, there is evidence that behavioural choices and the time allocated to making these choices differ by gender [58]. In our analysis, gender was a significant covariate for each exposure variable (i.e. never/ever, number of activities, and frequency). Specifying interaction terms between cultural participation and sex, we found statistically significant differences for ‘association and club meeting activities’ and parish work for CVD-related mortality, and ‘museum and art exhibition’ and dance for cancer-related mortality. We found that club meetings reduce the risk of CVD-related mortality among women by 36%, and that music, singing, and theatre engagement may reduce cancer-related mortality among men by 27%. Further, men who engaged in creative activities less than once a week showed a significantly (33%) lower risk of CVD-related mortality, whereas, for women the weekly frequency did not seem to be of importance. We are not aware of any other studies that have examined gender differences in relation to frequency of cultural participation and CVD-related mortality. A women-only cohort found that frequent attendance of religious services is associated with a significantly lower risk of CVD- and cancer-related mortality, when compared to never attending religious services; women who attend more than once a week have a 27% and 21% lower risk of CVD-related mortality and cancer-related mortality, respectively [59]. In our study, parish work was associated with a reduced risk of CVD-related mortality by 47% among women, while this was not statistically significant which could be due to small sample reporting parish work, (n = 1410) it is a strong protective effect size. Similar to our findings, Eng et al. did not find religious-service attendance to be significantly associated with reduced CVD-related mortality among men [6].

Causal pathways in health are presumably complex, and there are several risk factors for disease onset and mortality. Stress is strongly associated with CVD incidence [60], and is associated with depression and metabolic abnormalities that increase CVD risk [61]; further, chronic psychosocial stress modifies the association between inflammation and CVD [62]. A previous meta-analysis found chronic stressors to be associated with suppression of cellular and hormonal measures [63]. Additionally, stress may promote the initiation and progression of some types of cancer [64], thereby influencing cancer-related mortality [23]. The immune system and stress response seem to be of particular importance in regard to cancer [64–66], with immunological involvement varying across different cancers [64]. Psychological stress, both among healthy individuals experiencing stress and individuals with cancer-related psychological stress, is linked to the downregulation of immune responses immune responses, which has implications regarding cancer progression. Engaging in cultural events could promote immune functions by serving as a buffer against stress [23]. For example, interventions involving dance-movement therapy groups have shown positive effects regarding stress reduction [67], and art therapy has been found to increase overall coping resources among women with breast cancer [18]. A physically active lifestyle strengthens the ability to manage stress exposure and stress-related disorders [68]; in particular, cardiorespiratory fitness moderates stress and seems to be associated with fewer symptoms of depression and burnout [68]. Cultural activities can counteract adverse stress-related effects by promoting social networks and resilience [69, 70]. We suggest new studies regarding fair access to participation in cultural life, not least in view of the possible stress reducing effects from cultural engagement.
In observational studies such as this, causality is difficult to demonstrate. Cultural participation may serve as a proxy for other factors [71], such as social capital and factors related to SES. Fancourt and Steptoe explored cultural engagement in relation to mental health, and found it to be independent of socioeconomic status [72]. Another important public health aspect is the mental health challenges in the population. Anxiety and depression are prevalent conditions and found to be barriers for cultural engagement by Fancourt et al. [73]. Those participating in cultural activities may also be a healthier population than non-participants, and frequent attendees may be healthier than those who seldom participate. When compared to less-active people, such people may have greater knowledge, network support (representing a support mechanism), and ability to take advantage of knowledge regarding lifestyle and treatment options, and some may have access to private health-care financing through private insurance. Disease onset may encourage people to adopt healthier lifestyles, strengthening factors that improve their psychological and physical health, well-being, and quality of life, helping them to enjoy life.

**Strengths and limitations**

This study involved data for a large population-representative cohort that had an acceptable response rate and obtained rich information regarding a range of receptive and creative activities. The survey collected information on important confounders. A major strength is this research’s exploration of the risk of cause-specific mortality for a range of receptive and creative activities. Participants were blinded to future research questions when invited to participate in the HUNT3 Survey, which reduced social-desirability bias. Lastly, the use of cause of death data from the national register provided high degrees of coverage and completeness regarding cause-specific mortality.

Limitations include a lack of adjustment for changes over the follow-up period in relevant characteristics, health, and behaviours; further, possible joint effects of multiple risk factors (e.g., a cluster of risk factors within a single individual) and comorbidities were not examined. Some of the activities could not be separated (e.g., music, singing, and theatre). In addition, isolating activities is complex, as participating in creative activities could increase the likelihood of attending a concert, theatre, and/or cinema, or vice-versa. Consequently, the single-effect estimates may be confounded and may have measured attributable effects from other activities. Furthermore, other activities may be more strongly linked to sub-causes of mortality within the CVD and cancer categories. Statistically, we took a conservative approach by presenting 99% CIs; this was because we performed multiple testing and used 99% CIs to limit the type I error rate.

**Conclusion**

The results of this study have important implications for research, leisure-service providers and policy-makers. Researchers should continue to explore casual paths between stress reducing, social capital and mental well-being effects from cultural engagement among the general population. Leisure-service providers should increase the opportunities to engage in outdoor recreational activities, increase the number of clubs with affordable memberships, and create more opportunities to consistently engage in music, singing, and theatre. Policy-makers should review whether there is sufficient access to museums and artistic events across all regions of the country. Such activities will increase social interaction in the community, foster psychosocial benefits and, hopefully, promote and maintain health and enhance longevity.
Supporting information

S1 Fig. Diversity of receptive activities in association with CVD mortality, \(n = 35,902\). The HUNT Study (2006–08). *Number of activities from 1, 2 or maximum 3–4 activities attended, for the total sample and stratified for genders.

(TIF)

S2 Fig. Diversity of creative activities in association with CVD mortality, \(n = 35,902\). The HUNT Study (2006–08). *Number of activities from 1, 2 or maximum 3–5 activities engaged in, for the total sample and stratified for genders.

(TIF)

S3 Fig. Total diversity of activities, combined receptive and creative activities, in association with CVD mortality, \(n = 35,902\). *Number of activities from 1, 2 and up to maximum 7–9 activities engaged in, for the total sample and stratified for genders.

(TIF)

S4 Fig. Diversity of receptive activities in association with cancer mortality, \(n = 35,902\). The HUNT Study (2006–08). *Number of activities from 1, 2 or maximum 3–4 activities engaged in, for the total sample and stratified for genders.

(TIF)

S5 Fig. Diversity of creative activities in association with cancer mortality, \(n = 35,902\). The HUNT Study (2006–08). *Number of activities from 1, 2 or maximum 3–5 activities engaged in, for the total sample and stratified for genders.

(TIF)

S6 Fig. Total diversity of activities, combined receptive and creative activities, in association with cancer mortality, \(n = 35,902\). The HUNT Study (2006–08). *Number of activities from 1, 2 up to maximum 7–9 activities engaged in, for the total sample and stratified for genders.

(TIF)

Acknowledgments

The Trøndelag Health Study (The HUNT Study) is a collaboration between HUNT Research Centre, (Faculty of Medicine and Health Sciences, NTNU, Norwegian University of Science and Technology), Trøndelag County Council, Central Norway Health Authority, and the Norwegian Institute of Public Health. Data on cause of death were obtained from the Norwegian Cause of Death Registry.

I would confirm that all authors have seen and approved the manuscript as submitted. I certify that each author participated sufficiently in the study conception or design, data analysis or interpretation, and drafting or revision of the manuscript, so that each author takes responsibility for the validity, integrity, and objectivity of the entire study.

The corresponding author confirms on behalf of all authors that there have been no involvements that might raise the question of bias in the work reported or in the conclusions, implications, or other competing interests.

Author Contributions

Conceptualization: Bente I. Løkken, Dafna Merom, Erik R. Sund, Steinar Krokstad, Vegar Rangul.
Data curation: Bente I. Løkken.

Formal analysis: Bente I. Løkken, Dafna Merom, Erik R. Sund.

Funding acquisition: Bente I. Løkken, Steinar Krokstad, Vegar Rangul.

Investigation: Bente I. Løkken.

Methodology: Bente I. Løkken, Dafna Merom, Erik R. Sund, Steinar Krokstad, Vegar Rangul.

Project administration: Bente I. Løkken.

Supervision: Vegar Rangul.

Validation: Bente I. Løkken, Dafna Merom, Erik R. Sund.

Visualization: Bente I. Løkken, Vegar Rangul.

Writing – original draft: Bente I. Løkken, Dafna Merom.

Writing – review & editing: Bente I. Løkken, Dafna Merom, Erik R. Sund, Steinar Krokstad, Vegar Rangul.

References

1. World Health Organization (WHO). A prioritized research agenda for prevention and control of NCDs: CVD, cancer, chronic respiratory disease, diabetes. Geneva: 2011 9789241564205.

2. Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. The Lancet. 2006; 367(9524):1747–57. https://doi.org/10.1016/S0140-6736(06)68770-9 PMID: 16731270

3. Krokstad S, Ding D, Grunseit AC, Sund ER, Holmen TL, Rangul V, et al. Multiple lifestyle behaviours and mortality, findings from a large population-based Norwegian cohort study—The HUNT Study. (Nord-Trandelag Health Study)(Report). BMC Public Health. 2017; 17(1). https://doi.org/10.1186/s12889-016-3993-x PMID: 28068991

4. Davies C, Pescud M, Anwar-McHenry J, Wright P. Arts, public health and the National Arts and Health Framework: a lexicon for health professionals. Aust N Z J Public Health. 2016; 40(4):304–6. https://doi.org/10.1111/1753-6405.12545 PMID: 27372460

5. WHO. What is the evidence on the role of the arts in improving health and well-being? A scoping review (2019). http://www.euro.who.int/en/publications/abstracts/what-is-the-evidence-on-the-role-of-the-arts-in-improving-health-and-well-being-a-scoping-review-2019: 2019 Contract No.: ISBN 978 92 890 5455 3.

6. Eng PM, Rimm EB, Fitzmaurice G, Kawachi I. Social Ties and Change in Social Ties in Relation to Subsequent Total and Cause-specific Mortality and Coronary Heart Disease Incidence in Men. Am J Epidemiol. 2002; 155(8):700–9. https://doi.org/10.1093/aje/155.8.700 PMID: 11943687

7. Holt-Lunstad J, Smith TB, Layton JB, Brayne C. Social Relationships and Mortality Risk: A Meta-analytic Review (Social Relationships and Mortality). PLoS Med. 2010; 7(7):e1000316. https://doi.org/10.1371/journal.pmed.1000316 PMID: 20668659

8. Yang YC, Boen C, Gerken K, Li T, Schorp K, Harris KM, et al. Social relationships and physiological determinants of longevity across the human life span. Proc Natl Acad Sci U S A. 2016; 113(3):578–83. https://doi.org/10.1073/pnas.1511085112 PMID: 26729882

9. Boen CE, Barrow DA, Bensen JT, Farman L, Gerstel A, Hendrix LH, et al. Social Relationships, Inflammation, and Cancer Survival. Cancer Epidemiology Biomarkers &amp; Prevention. 2018. https://doi.org/10.1158/1055-9965.EPI-17-0836 PMID: 29475966

10. Valtorta NK, Kanaan M, Gilbody S, Ronzoni S, Hanratty B. Loneliness and social isolation as risk factors for coronary heart disease and stroke: systematic review and meta-analysis of longitudinal observational studies. Heart. 2016; 102(13):1009. https://doi.org/10.1136/heartjnl-2015-308790 PMID: 27091846

11. Katz-Gerro T. Cultural Consumption and Social Stratification: Leisure Activities, Musical Tastes, and Social Location. Sociological Perspectives. 1999; 42(4):627–46. https://doi.org/10.2307/1389577

12. Davies C, Rosenberg M, Knuiman M, Ferguson R, Pikora T, Slatter N. Defining arts engagement for population-based health research: Art forms, activities and level of engagement. Arts Health. 2012; 4. https://doi.org/10.1080/17533015.2012.656201
13. Staricoff RL. Arts in health: a review of the medical literature. Arts Council England, 2004 Contract No.: Research report 36.

14. Cuypers KF, Knudtsen MS, Sandgren M, Krokstad S, Wikström BM, Theorell T. Cultural activities and public health: research in Norway and Sweden. An overview. Arts & Health. 2011; 3(1):6–26. https://doi.org/10.1080/17533015.2010.481288

15. Theorell T, Osika W, Leineweber C, Magnnusson Hanson L, Bojner Horwitz E, Westerlund H. Is cultural activity at work related to mental health in employees? Int Arch Occup Environ Health. 2013; 86(3):281–8. https://doi.org/10.1007/s00420-012-0762-8 PMID: 22456978

16. White J. Effects of relaxing music on cardiac autonomic balance and anxiety after acute myocardial infarction. Am J Crit Care. 1999; 8(4):220–30. PMID: 10392221

17. Warran K, Fancourt D, Perkins R. The experience and perceived impact of group singing for men living with cancer: A phenomenological study. Psychology of Music. 2019; 47(6):874–89. https://doi.org/10.1177/0305735619854526

18. Öster I, Svensk A-C, Magnnusson EVA, Thyme KE, Sjödin M, Åström S, et al. Art therapy improves coping resources: A randomized, controlled study among women with breast cancer. Palliative and Supportive Care. 2006; 4(1):57–64. Epub 2006/06/29. https://doi.org/10.1017/s147895150606007x PMID: 16889324

19. Boyde C, Linden U, Boehm K, Osterman T. The Use of Music Therapy During the Treatment of Cancer Patients: A Collection of Evidence. Global advances in health and medicine. 2012; 1(5):24. https://doi.org/10.7453/gahmj.2012.1.5.009 PMID: 27257528

20. Renton A, Phillips G, Daykin N, Yu G, Taylor K, Petticrew M. Think of your art-eries: Arts participation, behavioral cardiovascular risk factors and mental well-being in deprived communities in London. Public Health. 2012; 126:S57–S64. https://doi.org/10.1016/j.puhe.2012.05.025 PMID: 22766259

21. Merom D, Ding D, Stamatelakis E. Dancing Participation and Cardiovascular Disease Mortality. A Pooled Analysis of 11 Population-Based British Cohorts. Am J Prev Med. 2016; 50(6):756–60. https://doi.org/10.1016/j.amepre.2016.01.004 PMID: 26944521

22. Bygren LO, Johansson S-E, Konlaan BB, Gribkovski AM, Wilkinson AV, Sjöström M. Attending cultural events and cancer mortality: A Swedish cohort study. Arts & Health. 2009; 1(1):64–73. https://doi.org/10.1080/17533010802528058

23. Väänänen A, Murray M, Koskinen A, Vahtera J, Kouvonen A, Kivimäki M. Engagement in cultural activities and cause-specific mortality: Prospective cohort study. Prev Med. 2009; 49(2):142–7. https://doi.org/10.1016/j.ypmed.2009.06.026 PMID: 19589351

24. Holmen J, Nguyen C, Haapnes O, Rangul V, Espnes GA. Kultur og helse i HUNT—En metodeevaluering. Nor J Epidemiol. 2016; 26(1–2):139–44.

25. HUNT databank, NTNU [Internet]. (HUNT). 2017. https://hunt-db.medisin.ntnu.no/hunt-db/#/instrument/229.

26. Langhammer A, Romundstad P, Hegglund J, Holmen J. The HUNT study: participation is associated with survival and depends on socioeconomic status, diseases and symptoms. BMC Med Res Methodol. 2012; 12(1):1–14. https://doi.org/10.1186/1471-2288-12-143 PMID: 22978749

27. Pedersen AG, Ellingsen CL. Data quality in the Causes of Death Registry. Tidskr Nor Lægeforen. 2015; 8(135):768–70. PMID: 25947599

28. World Health Organization (WHO). Global recommendations on physical activity for health. Geneva: 2010.

29. Fancourt D, Steptoe A. The art of life and death: 14 year follow-up analyses of associations between arts engagement and mortality in the English Longitudinal Study of Ageing. BMJ. 2019; 367:l6377. https://doi.org/10.1136/bmj.l6377 PMID: 31852659

30. Donneyong MM, Taylor KC, Kerber RA, Hornung CA, Scragg R. Is outdoor recreational activity an independent predictor of cardiovascular disease mortality—NHANES III? Nutrition, Metabolism and Cardiovascular Diseases. 2016; 26(8):735–42. https://doi.org/10.1016/j.numecd.2016.02.006.

31. Donneyong MM, Taylor KC, Kerber RA, Hornung CA. Outdoor Leisure-Time Physical Activity, Serum Vitamin D and Their Effects on Cvd Mortality Risk. Ann Epidemiol. 2012; 22(9):666-. https://doi.org/10.1016/j.annepidem.2012.06.028
35. Sjogren K, Hansson E, Stjernberg L. Parenthood and factors that influence outdoor recreational physical activity from a gender perspective. BMC Public Health. 2011; 11: ArtN 93. https://doi.org/10.1186/1471-2458-11-93 PMID: 21310038

36. Saliman D. Time spent being sedentary: an emerging risk factor for poor health. Brit J Gen Pract. 2019; 69(683):278–9. https://doi.org/10.3399/bjgp19X703781 PMID: 31147321

37. Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer-Cheung AE, et al. Sedentary Behavior Research Network (SBRN)–Terminology Consensus Project process and outcome. International Journal of Behavioral Nutrition and Physical Activity. 2017; 14(1):75. https://doi.org/10.1186/s12966-017-0525-8 PMID: 28599680

38. Rangul V, Sund ER, Mork PJ, Roe OD, Bauman A. The associations of sitting time and physical activity on total and site-specific cancer incidence: Results from the HUNT study, Norway. PLoS One. 2018; 13(10):e0206015. Epub 2018/10/24. https://doi.org/10.1371/journal.pone.0206015 PMID: 30352079.

39. Autenrieth CS, Baumert J, Baumeister SE, Fischer B, Peters A, Doring A, et al. Association between domains of physical activity and all-cause, cardiovascular and cancer mortality. Eur J Epidemiol. 2011; 26(2):91–9. Epub 2010/12/15. https://doi.org/10.1007/s10654-010-9517-6 PMID: 21153912.

40. Lynch BM. Sedentary behavior and cancer: a systematic review of the literature and proposed biological mechanisms. Cancer Epidemiol Biomarkers Prev. 2010; 19(11):2691–709. Epub 2010/09/14. https://doi.org/10.1158/1055-9965.EPI-10-0815 PMID: 20833969.

41. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. CMAJ. 2006; 174(6):801–9. Epub 2006/03/15. https://doi.org/10.1503/cmaj.051351 PMID: 16534088.

42. Mora S, Cook N, Buring JE, Ridker PM, Lee IM. Physical activity and reduced risk of cardiovascular events: Potential mediating mechanisms. Circulation. 2007; 116(19):2110–8. https://doi.org/10.1161/CIRCULATIONAHA.107.729939 PMID: 17967770

43. Livie CJ, Ozemek C, Carbone S, Katzmarzyk PT, Blair SN. Sedentary Behavior, Exercise, and Cardiovascular Health. Circ Res. 2019; 124(5):799–815. Epub 2019/03/01. https://doi.org/10.1161/CIRCRESAHA.118.312669 PMID: 30817262.

44. Chomisteak AK, Manson JE, Stefanick ML, Lu B, Sands-Lincoln M, Going SB, et al. Relationship of Sedentary Behavior and Physical Activity to Incident Cardiovascular Disease. J Am Coll Cardiol. 2013; 61(23):2346–54. https://doi.org/10.1016/j.jacc.2013.03.031 PMID: 23583242

45. Stamatakis E, Rogers K, Ding D, Berrigan D, Chau J, Hamer M, et al. All-cause mortality effects of replacing sedentary time with physical activity and sleeping using an isotemporal substitution model: a prospective study of 201,129 mid-aged and older adults. Int J Behav Nutr Phys Act. 2015; 12:121. Epub 2015/10/01. https://doi.org/10.1186/s12966-015-0280-7 PMID: 26419654.

46. White MP, Pahl S, Ashbullby K, Herbert S, Depledge MH. Feelings of restoration from recent nature visits. J Environ Psychol. 2013; 35:40–51. https://doi.org/10.1016/j.jenrvp.2013.04.002.

47. Holick MF. Sunlight and vitamin D for bone health and prevention of autoimmune diseases, cancers, and cardiovascular disease. The American Journal of Clinical Nutrition. 2004; 80(6):1678S–88S. https://doi.org/10.1093/ajcn/80.6.1678S PMID: 15585788

48. Garland CF, Garland FC, Gorham ED, Lipkin M, Newmark H, Mohr SB, et al. The role of vitamin D in cancer prevention. Am J Public Health. 2006; 96(2):252–61. Epub 2005/12/27. https://doi.org/10.2105/AJPH.2004.045260 PMID: 16380576.

49. Fancourt D, Steptoe A, Cadar D. Cultural engagement and cognitive reserve: museum attendance and dementia incidence over a 10-year period. The British Journal of Psychiatry. 2018; 213(5):661–3. Epub 2018/07/20. https://doi.org/10.1192/bjp.2018.129 PMID: 30025547

50. Fancourt D, Steptoe A, Cadar D. Community engagement and dementia risk: time-to-event analyses from a national cohort study. J Epidemiol Community Health. 2020; 74(1):17. https://doi.org/10.1136/jech-2019-213029 PMID: 31662344

51. Chatterjee HJ, Camic PM. The health and well-being potential of museums and art galleries. Arts & Health. 2015; 7(3):183–6. https://doi.org/10.1080/17533015.2015.1065594

52. Ander E, Thomson L, Noble G, Lanceley A, Menon U, Chatterjee H. Generic well-being outcomes: towards a conceptual framework for well-being outcomes in museums. Museum Management and Curatorship. 2011; 26(3):237–59. https://doi.org/10.1080/09647775.2011.585798

53. Rozanski A, Blumenthal JA, Kaplan J. Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy. Circulation. 1999; 99(16):2192–217. Epub 1999/04/27. https://doi.org/10.1161/01.01.12.016.12192 PMID: 10217662.

54. Thomson LJ, Ander EE, Menon U, Lanceley A, Chatterjee HJ. Enhancing Cancer Patient Well-Being With a Nonpharmacological, Heritage-Focused Intervention. J Pain Symptom Manage. 2012; 44(5):731–40. https://doi.org/10.1016/j.painsymman.2011.10.026 PMID: 22835481
55. Nunez MJ, Mana P, Linares D, Riveiro MP, Balboa J, Suarez-Quintanilla J, et al. Music, immunity and cancer. Life Sci. 2002; 71(9):1047–57. Epub 2002/06/29. https://doi.org/10.1016/s0024-3205(02)01796-4 PMID: 12088764.

56. Fancourt D, Ockelford A, Belai A. The psychoneuroimmunological effects of music: A systematic review and a new model. Brain Behav Immun. 2014; 36:15–26. https://doi.org/10.1016/j.bbi.2013.10.014 PMID: 24157429.

57. Ostan R, Monti D, Gueresi P, Bussolotto M, Franceschi C, Baggio G. Gender, aging and longevity in humans: an update of an intriguing/neglected scenario paving the way to a gender-specific medicine. Clin Sci (Lond). 2016; 130(19):1711–25. Epub 2016/08/25. https://doi.org/10.1042/cs20160004 PMID: 27555614.

58. Muñiz C, Rodríguez P, Suárez MJ. The Allocation of Time to Sports and Cultural Activities: An Analysis of Individual Decisions. International Journal of Sport Finance. 2011; 6(3):245–64.

59. Li S, Stampfer MJ, Williams DR, VanderWeele TJ. Association of Religious Service Attendance With Mortality Among Women. JAMA Intern Med. 2016; 176(6):777–85. Epub 2016/05/18. https://doi.org/10.1001/jamainternalmed.2016.1615 PMID: 27183175.

60. Ippoliti F, Canitano N, Businaro R. Stress and Obesity as Risk Factors in Cardiovascular Diseases: A Neuroimmune Perspective. J Neuroimmune Pharmacol. 2013; 8(1):212–26. https://doi.org/10.1007/s11481-012-9432-6 PMID: 23329173.

61. Vargas J, Junco M, Gomez C, Lajud N. Early Life Stress Increases Metabolic Risk, HPA Axis Reactivity, and Depressive-Like Behavior When Combined with Postweaning Social Isolation in Rats. (Research Article). PLoS One. 2016; 11(9):e0162665. https://doi.org/10.1371/journal.pone.0162665 PMID: 27611197.

62. Lazarrino AI, Hamer M, Gaze D, Collinson P, Rumley A, Lowe G, et al. The interaction between systemic inflammation and psychosocial stress in the association with cardiac troponin elevation: A new approach to risk assessment and disease prevention. Prev Med. 2016; 93:46–52. https://doi.org/10.1016/j.ypmed.2016.09.018 PMID: 27663429.

63. Segerstrom SC, Miller GE. Psychological stress and the human immune system: a meta-analytic study of 30 years of inquiry. Psychol Bull. 2004; 130(4):601–30. Epub 2004/07/15. https://doi.org/10.1037/0033-2909.130.4.601 PMID: 15250815.

64. Reiche EMV, Nunes SOV, Morimoto HK. Stress, depression, the immune system, and cancer. The Lancet Oncology. 2004; 5(10):617–25. https://doi.org/10.1016/S1470-2045(04)01597-9 PMID: 15465465.

65. Kiecolt-Glaser JK, Glaser R. Psychoneuroimmunology and cancer: fact or fiction? Eur J Cancer. 1999; 35(11):1603–7. https://doi.org/10.1016/s0959-8049(99)00197-5 PMID: 10673969.

66. Havranek EP, Mujahid MS, Barr DA, Blair IV, Cohen MS, Cruz-Flores S, et al. Social Determinants of Risk and Outcomes for Cardiovascular Disease: A Scientific Statement From the American Heart Association. Circulation. 2015; 132(9):873–98. Epub 2015/08/05. https://doi.org/10.1161/CIR.0000000000000228 PMID: 26240271.

67. Bräuning I. Dance movement therapy group intervention in stress treatment: a randomized controlled trial (RCT). Arts Psychother. 2012; 39.

68. Gerber M, Lindwall M, Lindegård A, Börjesson M, Jonssdott IHH. Cardiorespiratory fitness protects against stress-related symptoms of burnout and depression. Patient Educ Couns. 2013; 93(1):146–52. https://doi.org/10.1016/j.pec.2013.03.021 PMID: 23623176.

69. Theorell T. Psychophysiological links between cultural activities and public health. In: Clift S, Camic PM, editors. Creative Arts, Health, and Wellbeing International perspectives on practice, policy, and research: Oxford University Press; 2016. p. 65–72.

70. Konlaan B, Theobald H, Bygren LO. Leisure time activity as a determinant of survival: A 26-year follow-up of a Swedish cohort. Public Health. 2002; 116(4):227–30. https://doi.org/10.1038/sj.ph.1900851 PMID: 12087462.

71. Theorell T, Ullén F. Epidemiological studies of the relationship between cultural experiences and public health. In: Clift S, Camic PM, editors. Creative Arts, Health, and Wellbeing International perspectives on practice, policy, and research: Oxford University Press; 2016. p. 55–63.

72. Fancourt D, Steptoe A. Cultural engagement and mental health: Does socio-economic status explain the association? Soc Sci Med. 2019; 236. https://doi.org/10.1016/j.socscimed.2019.112425 PMID: 31336219.

73. Fancourt D, Baxter L, Lorenzatto F. Barriers and enablers to engagement in participatory arts activities amongst individuals with depression and anxiety: quantitative analyses using a behaviour change framework. BMC Public Health. 2020; 20(1):272–12. https://doi.org/10.1186/s12889-020-8337-1 PMID: 32106643.