Master of Public Health

Master de Santé Publique

Assessing the CANCERLESS Health Navigation Model's Impact on Cancer Risk Factors among People Experiencing Homelessness in Four European Countries.

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List of Acronyms

Abbreviation	Full Term
PEH	People Experiencing Homelessness
CANCERLESS	Cancer prevention and early detection among the homeless population in Europe: Co-adapting and implementing the Health Navigator Model
ETHOS	European Typology of Homelessness and Housing Exclusion
HRQoL	Health-Related Quality of Life
EQ-5D-5L	EuroQol 5 Dimensions 5 Levels Questionnaire
MCAR	Missing Completely At Random
MAR	Missing At Random
MNAR	Missing Not At Random
MICE	Multiple Imputation by Chained Equations
CLMM	Cumulative Link Mixed Model
T0	Baseline (first measurement time point)
T1	Intermediate (4 weeks – measurement)
T2	Exit/Intervention concluded (final measurement time point)
T3	Follow-up after 6 months
CIDMA	CANCERLESS Intervention Data Management Application
UK	United Kingdom
EU	European Union
UPV	Universitat Politècnica de València
PIR	Proportional Incidence Ratio
COVID-19	Coronavirus Disease 2019
CI	Confidence Intervals
R	R Statistical Software

Abstract:

People experiencing homelessness (PEH) face significant health barriers. They are at higher risk for cancer and chronic diseases due to financial hardship, social stigma, and increased prevalence of risk behaviours such as smoking, poor diet, and low physical activity. This project aimed to assess whether the tailored health navigation model, CANCERLESS, could improve modifiable cancer risk behaviours and improve health outcomes among PEH. The intervention aimed to address modifiable cancer risk factors and enhance cancer prevention through targeted activities, including behavioural support, education, and social services.

The CANCERLESS intervention was implemented over nineteen months across 16 sites in Austria, Greece, Spain, and the UK. Participants received support from trained health navigators. The study used data from 277 PEH who completed the intervention. Data were collected at baseline (T0) and after the intervention (T2), using standardised questionnaires to measure demographics, health behaviours, and quality of life. The analysis included descriptive statistics, multiple imputation for missing data, and repeated-measures ordinal logistic regression.

The results revealed significant improvements in physical activity and homelessness situation, with greater effects among participants with higher levels of education and those without legal documentation. However, there was a notable decline in condom use and limited change in smoking or alcohol use, suggesting that not all cancer risk factors improved. These findings emphasise the challenges of achieving lasting health behavioural change and the importance of addressing structural barriers. The high dropout rate also stresses the need for improved adherence strategies for highly mobile populations.

Nevertheless, the findings show that tailored, navigation-based models can make a positive difference for groups often overlooked by healthcare systems. To fully address the diverse needs of PEH, future interventions must be flexible, sustained, and co-created with them. Above all, cancer should not become yet another barrier for individuals already facing daily uncertainty and hardship.

Key words: Homelessness, cancer prevention, health navigation, modifiable risk factors.

Évaluation de l'impact du modèle de navigation en santé CANCERLESS sur les facteurs de risque de cancer chez les personnes sans-abri dans quatre pays européens.

Résumé :

Les personnes sans-abri (PSA) font face à des barrières de santé significatives. Elles sont à un risque plus élevé de cancer et de maladies chroniques en raison de difficultés financières, de stigmatisation sociale et d'une prévalence accrue de comportements à risque tels que le tabagisme, une mauvaise alimentation et une faible activité physique. Ce projet visait à évaluer si le modèle de navigation en santé personnalisé, CANCERLESS, pouvait améliorer les comportements de à risque modifiables liés au cancer et améliorer les résultats de santé parmi les PSA. L'intervention visait à aborder les facteurs de risque modifiables du cancer et à renforcer la prévention du cancer par le biais d'activités ciblées, y compris dont le soutien comportemental, l'éducation et les services sociaux.

L'intervention CANCERLESS a été mise en œuvre sur dix-neuf mois dans 16 sites en Autriche, en Grèce, en Espagne et au Royaume-Uni. Les participants ont reçu un soutien de la part de navigateurs de santé formés. L'étude a utilisé des données de 277 PEH qui ont complété l'intervention. Les données ont été collectées à la ligne de base au départ/au début de l'étude ? (T0) et après l'intervention (T2), à l'aide de questionnaires standardisés pour mesurer les données démographiques, les comportements de santé et la qualité de vie. L'analyse a inclus des statistiques descriptives, une imputation multiple pour les données manquantes et une régression logistique ordinale à mesures répétées.

Les résultats ont révélé des améliorations significatives de l'activité physique et de la situation de sans-abrisme, avec des effets plus marqués parmi les participants ayant des niveaux d'éducation plus élevés et ceux sans documentation légale. Cependant, il y a eu une baisse notable de l'utilisation des préservatifs et peu de changement dans le tabagisme ou la consommation d'alcool, ce qui suggère que tous les facteurs de risque de cancer ne se sont pas améliorés. Ces résultats soulignent les défis d'atteindre" les obstacles à l'atteinte d'un"/"les difficultés à atteindre un" un changement durable des comportements de santé et l'importance d'aborder les barrières structurelles. Le taux d'abandon élevé souligne également la nécessité de stratégies d'adhésion améliorées pour les populations très mobiles.

Néanmoins, les résultats montrent que des modèles de navigation personnalisés peuvent faire une différence positive pour des groupes souvent négligés par les systèmes de santé. Pour répondre pleinement aux besoins divers des PSA, les interventions futures doivent être flexibles, durables et co-créées avec eux. Avant tout, le cancer ne devrait pas devenir une autre barrière pour des individus déjà confrontés à l'incertitude et aux difficultés quotidiennes.

Mots-clés : Sans-abrisme, prévention du cancer, navigation en santé, facteurs de risque modifiables.

CHAPTER 1: Introduction

1.1 Context and Background

People experiencing homelessness (PEH) represent a priority population due to their significantly worsened health outcomes compared to the housed population. The Centers for Disease Control and Prevention indicates that PEH face a heightened risk of respiratory infections, including tuberculosis and COVID-19 [1]. Their living conditions contribute to chronic stress and uncertainty, resulting in an average lifespan 17.5 years shorter than that of the housed population [2]. When examining chronic conditions such as cancer, PEH tend to have poorer health outcomes, with higher incidence rates of both respiratory and female genital system cancers. Research shows that men who experience homelessness have a statistically significant higher proportional incidence ratio (PIR) of respiratory cancers (PIR = 1.51; 95% CI = 1.28 to 1.79), while women who experience homelessness exhibit an even higher PIR for female genital system cancers (PIR = 1.83; 95% CI = 1.31 to 2.55) [3]. Cancer ranks among the leading causes of death for adults experiencing homelessness, particularly affecting those aged 45 to 64 years. Notably, cancer was identified as the foremost cause of death among men who experience homelessness, with lung, liver, and colon cancers being the most prevalent [4]. This underscores the need for further research to elucidate the complex relationship between homelessness and cancer. Competing interests and immediate survival needs often overshadow engagement with preventative healthcare for PEH, with basic necessities such as food and shelter taking precedence.

Preventative healthcare is frequently regarded as a 'non-priority' by PEH, who face pressing challenges daily. Factors such as unstable housing, financial limitations, and inadequate access to health care establish systemic barriers that limit their engagement with preventive care [5]. Addressing these systemic barriers is crucial to ensuring equitable access to healthcare. Additionally, social stigma, which deems PEH as undeserving or burdensome, further complicates their ability to obtain necessary services [6]. The inflexible and fragmented nature of the healthcare system exacerbates these issues, hindering adherence to treatment plans and regular screenings [7,8].

A systematic literature review indicates several factors contributing to poor health outcomes among PEH, including high rates of tobacco smoking, which is linked to respiratory and cardiovascular diseases [9]. High alcohol consumption and substance misuse also exacerbate both physical and mental health conditions [10]. Furthermore, risks from unprotected sun exposure and inconsistent condom use elevate the chances of skin cancers and sexually

transmitted infections, respectively [11,12]. Nutritional deficiencies and obesity further complicate the health of PEH, leading to chronic conditions such as diabetes and hypertension [13,14]. All these risk factors are also strongly linked with an increased risk of different types of cancer and can act as comorbidities [3]. Furthermore, the fragmented healthcare system's inability to provide continuous and comprehensive care exacerbates these issues [15]. Addressing these risk factors through targeted interventions and accessible healthcare services is essential to improving health outcomes and the cancer experience from diagnosis to treatment among PEH.

One emerging alternative to help priority populations address their healthcare and social needs involves navigation interventions. In the context of PEH, the navigation model could help bridge systemic gaps by empowering individuals to access and engage with healthcare services effectively, regardless of their prior knowledge or social situation [7]. For PEH, who often struggle with disorganised healthcare systems and competing priorities, navigation models offer a structured framework alternative to improve their health outcomes. Prior research on navigation has demonstrated its potential to mitigate barriers, including stigma, lack of trust in healthcare providers, and critical logistical challenges such as transportation and language barriers [10]. Navigation in the context of cancer prevention has immense potential because it can facilitate timely screenings, lifestyle changes, and adherence to prevention and screening protocols. However, there is still a significant gap in understanding how these models can be tailored to the specific and complex difficulties experienced by PEH when accessing healthcare systems. In this context, the CANCERLESS: Cancer prevention and early detection among the homeless population in Europe: Co-adapting and implementing the Health Navigator Model project represents a novel approach by adapting the navigation model to PEH, focusing on modifiable cancer risk factors such as substance use, poor nutrition, and risky sexual behaviours [16]. By empowering PEH and reducing systemic obstacles, this intervention can represent a meaningful change in cancer prevention and care for PEH, addressing multiple urgent public health needs simultaneously.

1.2 Purpose of the Study

Despite promising findings, the analysis of the effects of navigation models and interventions on cancer risk factors, especially within priority populations, is limited. Navigation interventions, which assist individuals in connecting and becoming a part of the healthcare system, have shown potential in addressing cancer risk factors such as tobacco use, alcohol consumption, and inadequate nutrition [10]. However, studies and reports are scarce on how these models impact priority and underserved populations, such as people experiencing homelessness. This lack of research highlights the need for further investigation to understand the effectiveness and adaptability of navigation interventions.

What distinguishes CANCERLESS: Cancer prevention and early detection among the homeless population in Europe is its tailored application of the Health Navigator Model within the context of homelessness, specifically addressing the unique barriers faced by this group. While navigation models have been explored in general and clinical populations, few, if any, have been tailored to address such barriers, including social exclusion, fragmented service provision, and pervasive mistrust toward healthcare institutions [16]. The intervention is person-centred, and while peer navigators were present at one pilot site, most navigators were trained professionals operating within trusted community settings to foster engagement with preventative cancer care.

This thesis focuses on assessing the effectiveness of the CANCERLESS project in improving cancer prevention in PEH. Considering the challenges these priority subpopulations face, such as social stigma and competing immediate needs, it is essential to conduct more in-depth studies to understand their needs better. The findings of the following research could have significant implications for public health policy and the design of interventions for other underserved groups. Given these challenges and the limited existing research on navigation interventions for PEH, this study aims to evaluate the effectiveness of the CANCERLESS project in improving cancer prevention and early detection among this priority population.

This study aims to contribute to the evidence-based conceptual framework of navigation in healthcare, focusing on cancer prevention in PEH. Further analysis of the collected data can also help us examine differences between subgroups, including social context and duration of homelessness, recognising the impact of an individual's type of homelessness according to the European Typology of Homelessness and Housing Exclusion (ETHOS) [17]. By considering these factors, we aim to deliver targeted interventions and enhance health outcomes for individuals experiencing homelessness, ultimately contributing to a more inclusive and effective healthcare system.

The present thesis was conducted within the framework of a larger, ongoing research project on cancer prevention and early detection among people experiencing homelessness in Europe. The principal focus of this work was the analysis of the CANCERLESS intervention's effects on modifiable cancer risk factors; however, participation in additional research activities, such as preparing secondary analysis reports and presenting a scientific article at a journal club, also contributed to the broader research environment. The analysis described forms the central component of the internship period. It will also serve as the foundation for a possible publication, supporting the dissemination of cancer research literature to the broader scientific community. All work was carried out in close collaboration with the project team to ensure alignment with overall research objectives and to enable the development and application of advanced analytical skills. This context provided an opportunity to engage with multiple aspects of public health research, with the thesis representing the main scientific contribution during this period and reflecting both independent initiative and integration within a multidisciplinary research effort.

1.3 Research Questions and/or Hypotheses

Main Research Question:

What is the effect of the CANCERLESS intervention on modifiable cancer risk factors among PEH in 4 pilot European countries?

Hypothesis:

We hypothesise that, from baseline (T0) to exit (T2), the intervention will be associated with statistically significant reductions in modifiable cancer risk factors, as measured using self-report questionnaires.

Secondary Research Questions:

In addition to the main research question, this study will explore several secondary questions to provide a more comprehensive understanding of the CANCERLESS intervention's impact:

- Are there differences in the effectiveness of the intervention across key subgroups, such as gender, age, legal status, country of birth or type of homelessness (as defined by the ETHOS typology)?
- How do changes in specific risk behaviours (e.g., smoking, alcohol use, dietary habits, physical activity, and sexual risk behaviours) vary from baseline to exit among participants?

CHAPTER 2: Methodology

2.1 Methodological Rationale

This study analyses secondary outcomes derived from data collected as part of the ongoing CANCERLESS project, which was implemented across four European countries. The rationale for focusing on these outcomes lies in the scope and scale of the CANCERLESS dataset, which provides comprehensive information on modifiable cancer risk factors among people experiencing homelessness (PEH). Analysing this dataset enables evaluation of intervention effectiveness in real-world settings and across diverse contexts, reducing potential biases associated with single-site or self-conducted data collection. Using a non-randomised, single-arm design reflects the practical and ethical considerations inherent in working with vulnerable populations, where randomisation and control groups may not always be feasible [18]. Analysing secondary outcomes is particularly valuable when working with hard-to-reach or priority populations, as it maximises the utility of existing resources and minimises participant burden [19].

However, such analyses have some limitations. The scope of possible analysis is limited by prior variable selection, and data collection cannot be adapted to emerging findings. Additionally, there is a potential for missing or incomplete data, which must be acknowledged and addressed through rigorous data cleaning and reporting [19]. Despite these challenges, the depth and novel nature of the CANCERLESS dataset offer a unique opportunity to investigate changes in cancer risk factors among PEH at a scale that primary data collection would usually struggle to achieve, considering time and resource limitations.

2.2 Study Design and Setting

The CANCERLESS project dataset was gathered from 16 pilot sites in Austria, Greece, Spain, and the United Kingdom between June 2022 and December 2023. According to the evaluation protocol, four main evaluation time points were planned: Baseline (T0), Intermediate at 4 weeks (T1), Intervention concluded (T2), and Follow-up after 6 months (T3). However, due to timeline constraints, T3 was not feasible. As a result, participants were evaluated at three time points: Baseline (T0), Week 4 (T1), and at the end of the intervention (T2). It is important to note that T1 was primarily qualitative and did not include the variables relevant to this analysis. Therefore, this study focuses on data collected at two-time points: baseline (T0) and exit (T2). This design

enables the assessment of changes in cancer risk behaviours following exposure to the intervention in real-world community and service settings.

The intervention was delivered directly at the pilot site settings, with health navigators acting as the primary agents. The unit of intervention delivery was primarily individual, tailored to the specific needs of each participant. Health navigators conducted one-on-one appointments to gather information, identify individual health needs, and provide ongoing personalised support. Primary prevention activities included referrals to cancer prevention educational resources (such as health promotion and cancer awareness workshops), facilitating access to vaccination programmes and health-promoting facilities like gyms, and supporting engagement in healthy lifestyle activities. Secondary prevention activities focused on navigator-guided referrals, arranging cancer screening appointments, and accompanying participants to medical visits, particularly when they faced barriers such as a lack of health insurance. The intervention was designed to be flexible, with the frequency and duration of navigator-participant interactions tailored to individual needs. It spanned approximately 19 months, aligning with the overall study period.

2.3 Data Source and Collection

The participants in this study consisted of people experiencing homelessness (PEH) who fit one of the categories defined by the European Typology of Homelessness and Housing Exclusion (ETHOS), a comprehensive framework for policy and academic research developed to work with PEH [20]. Eligible participants were aged 18 years or older, had not received a cancer diagnosis, had sufficient command of a spoken language at their respective pilot site, and provided informed consent. Recruitment was conducted through community organisations, shelters, outreach programmes, and healthcare facilities serving PEH.

Data were collected at two-time points: baseline (T0) and exit (T2), with a retention rate of approximately 42% (275 participants) and a loss to follow-up rate of about 58%. The dataset comprises responses to 180 questions at baseline and 184 at exit, including newly introduced items on intervention adherence at T2. Data collection followed standardised protocols established by the CANCERLESS consortium to ensure consistency across pilot sites.

Responses from PEH were collected via questionnaires at the 16 pilot sites and entered into the CIDMA, a platform developed and managed by the Universitat Politècnica de València (UPV). Participant responses were initially recorded on paper forms and subsequently digitised into CIDMA. All information was treated confidentially, with data stored in a pseudo-anonymous format

[21]. Prior to the present analysis, access was granted under an internship agreement with the project coordinators.

2.4 Instruments and Measures

The data collection and measurement instruments employ both quantitative and qualitative methods, following guidelines adapted and translated to the four local contexts (Austria, Greece, Spain, and the UK). Key variables assessed in the dataset include healthcare empowerment, health-related quality of life (HRQoL), risk behaviours (smoking, alcohol use, drug use, nutrition, sexual risk behaviours, physical activity, hygiene, and sun exposure), healthy lifestyle indicators, and self-rated health.

For analysis, smoking status was coded as a binary variable (daily smoking: yes/no). All other main risk behaviour variables, such as alcohol use, substance use, meal frequency, condom use, physical activity, vigorous physical activity, handwashing, and sun exposure, were treated as ordinal variables, each with defined categories reflecting frequency or intensity. This operationalisation allowed for the use of appropriate categorical and ordinal statistical models in the analysis. Standardised instruments included the Healthcare Empowerment Questionnaire and the EQ-5D-5L for quality of life assessment.

The healthcare empowerment questionnaire consists of 8 items that measure domains such as informed decision-making, self-perceived ability to navigate the healthcare system, and influence over one's health. The items are measured on a Likert scale, with higher scores equalling greater empowerment [22].

The EQ-5D-5L questionnaire was used for HRQoL because it is a widely recognised and standardised instrument that assesses health status across five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression, each with five levels of severity [23].

In addition, the study included several bespoke items and adapted questions explicitly designed to capture cancer risk behaviours and modifiable lifestyle risk factors relevant to people experiencing homelessness (PEH). Examples of these questions, as administered in the study, include:

- Do you currently smoke tobacco on a daily basis?
- If yes: How many cigarettes do you smoke per day?
- How often do you have a drink containing alcohol?

- Do you consume psychoactive substances?
- How many meals do you eat per day?
- How often have you had sexual intercourse and not used a condom?

Each variable was operationalised to facilitate categorical and ordinal analysis, with risk behaviours coded according to established definitions in the public health literature. The questionnaires were administered by trained staff or navigators familiar with the target population, optimising participant comfort and response accuracy [24].

For the scope of this research, only health data, risk behaviours, and modifiable lifestyle risk factors were included in the analysis. Including baseline and exit measures allows for assessing change within individuals and across the sample.

2.5 Ethical Considerations

The secondary data used in this analysis consisted of anonymised copies of the original database provided by the study organisers. The CANCERLESS project was approved by the Ethical Committee of the Medical University of Vienna, which served as the lead ethics committee; all other pilot sites obtained additional ethical approval from their local ethics committees or internal review boards. The ethical approval for this thesis was also obtained from the University of Sheffield, with application reference number 067025 (Appendix 2), confirming that this research involves only existing data and that the data have been robustly anonymised, which would make it unlikely to offend those who initially provided the data, should they become aware of it. Data privacy was strictly maintained, as all data were stored exclusively on a private computer, not transmitted or shared electronically, and all analyses were performed locally using R software.

2.6 Data Analysis Techniques

The analysis plan for this study was carefully designed to ensure transparency and methodological rigour in addressing the research questions established. Analyses were conducted sequentially, starting with a thorough exploration of the data and progressing to advanced inferential modelling. A strong emphasis was placed on appropriately handling missing data and accounting for the challenges of working with a highly mobile population such as PEH.

2.6.1 Descriptive Statistics

Descriptive statistics were first carried out to characterise the study sample at baseline, comparing key demographic and behavioural variables between participants who completed the study (Completers) and those lost to follow-up (Dropouts). Measures of central tendency and dispersion were used for continuous variables, while proportions and frequencies were used for categorical data. The initial analyses provided valuable insights into the representativeness of the analytic sample, informing the subsequent analytic steps and decisions.

A systematic approach to handling missing data was adopted due to the substantial proportion of missingness, primarily resulting from attrition between baseline and follow-up. The mechanisms of missingness were investigated using formal statistical tests (e.g. MCAR tests, logistic regression for predictors of missingness) to distinguish between data missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR) [25,26]. Evidence of MAR was identified for various key variables, such as vigorous physical activity (vgphactt0, vgphactt2), physical activity (phyactvt0, phyactvt2), and sexual risk behaviour (cndmusgt0, cndmusgt2), where missingness was significantly associated with observed characteristics, including age and smoking status. For these variables, multiple imputation by chained equations (MICE) was implemented using proportional odds logistic regression for ordinal variables, minimising bias and maximising statistical power [27]. For country of birth (cntrybrtt0), a separate "Unknown" category was created to preserve transparency regarding missingness. The analytic dataset was ultimately restricted to participants ("completers") who provided data at both baseline and follow-up, ensuring the validity of repeated-measures analyses and reducing reliance on imputed values for longitudinal change estimates.

2.6.2 Advanced Statistics

Inferential analyses were then conducted to assess the effect of the Intervention on modifiable cancer risk factors. McNemar's test was used to evaluate changes over time for paired categorical outcomes, while Wilcoxon signed-rank tests were employed for ordinal or non-normally distributed data. To more fully account for the repeated-measures design and the ordinal nature of several key outcomes, repeated-measures ordinal logistic regression—implemented as cumulative link mixed models (CLMM)—was used. These models incorporated random effects to account for within-subject correlations and allowed for the inclusion of covariates such as age, gender, education, and legal or migration status [28].

Subgroup analyses were conducted to investigate whether intervention effects varied according to demographic or structural variables, including gender, age group, ETHOS homelessness category, and EU versus non-EU migration status. For these analyses, separate models were run for each subgroup to examine within-group effects, rather than including interaction (cross-product) terms in the main models. This approach allowed for investigating effect heterogeneity and identifying groups that might benefit most or least from the intervention.

All analyses were performed using R statistical software (version 2024.12.1+563), with packages such as "mice" for multiple imputation [27] and "ordinal" for mixed-effects ordinal regression [29]. The threshold for statistical significance was set at $p < 0.05$. Sensitivity analyses were conducted to examine the robustness of findings under different imputation scenarios and analytic assumptions, particularly given the high attrition rate and the potential for reduced statistical power. The non-randomised, single-arm design and the substantial loss to follow-up are recognised as limitations; these factors may affect the generalisability of findings and the ability to detect more minor intervention effects. Nevertheless, the analytic approach was specifically chosen to maximise internal validity and provide the most accurate estimates possible within the constraints of the study design.

CHAPTER 3: Results

3.1 Descriptive Statistics: Completers vs. Dropouts

The initial descriptive analysis compared the baseline characteristics of participants who completed the CANCERLESS intervention, "completers", with those who dropped out ", dropouts", across four pilot European countries. The original dataset included 652 observations and 355 variables collected at two time points (T0 and T2). As depicted in Figure 1, a substantial proportion of data is missing, which was anticipated due to the high attrition rate in this priority and highly mobile population. Figure 2 further illustrates the proportion of missing values by variable, highlighting the need for robust strategies to handle missing data throughout the analysis.

The dataset was restricted to 19 modifiable cancer risk factors and four key demographic variables (gender, age, highest level of education and birth region), resulting in a subset of 652 participants at T0. Of these, 277 were classified as 'completers' and 375 as 'dropouts', based on the presence or absence of follow-up data. The subset data have a diverse demographic distribution: the median age at T0 was 48 years (range: 0–87), with males representing the majority (n = 418) and the most common education level being upper secondary (n = 196). Daily smokers were highly prevalent (n=419), and most participants reported infrequent alcohol (mode: "Never", n=282) and drug use (mode: "Never", n=499).

Frequency distributions revealed differences between completers and dropouts. Dropouts were more frequently found in lower education categories and in living situations associated with greater instability, such as "living rough" or staying in a night shelter. In contrast, 'completers' were more evenly distributed across education levels and housing situations, with a higher representation in the category 'temporarily with family/friends'. For health behaviours, daily smoking was reported by 255 dropouts (68%) versus 164 completers (59%). "Rarely or never" using condoms was reported by 123 dropouts (33%) and 87 completers (31%). Health-promoting behaviours, such as regular handwashing and physical activity, were marginally more common among completers, although both groups were generally clustered towards lower activity levels.

Regional representation also differed: Western Europe and the UK were the most common birth regions in both groups, but dropouts were disproportionately represented among participants from Latin America, North Africa, and Eastern Europe.

The dataset was then restricted to participants who provided data at both baseline and follow-up ("completers"), resulting in an analytic sample of 277 individuals. Figure 3 displays the pattern of missing data by variable among this completer group, providing a clearer picture of data completeness prior to imputation.

Following this comparison, missing data were imputed where appropriate to allow for robust statistical analyses. The imputed dataset reflected similar central tendencies to the raw data, with minor shifts in modes and frequencies (e.g., a slight increase in the mode for upper secondary education and daily smoking). These descriptive statistics establish the demographic and behavioural context for the subsequent longitudinal and inferential analyses.

Figure 1. Missing Data Heatmap Original Dataset T0 and T2
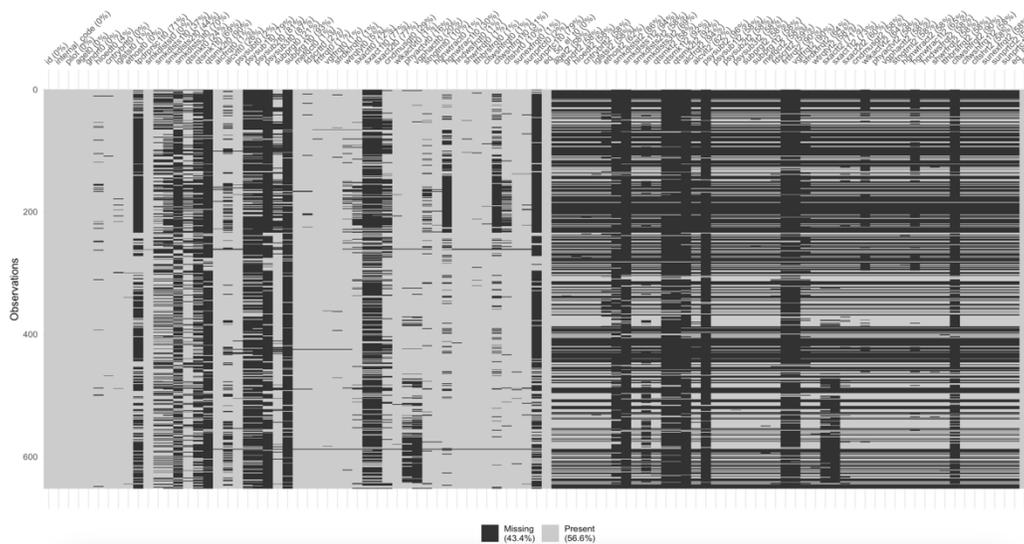
Fig 1. Missing Data Heatmap: This heatmap visualises the extensive missingness across variables and participants for the original dataset, with measurements from T0 and T2, particularly the variables related to the T2 measurements.

Figure 2. Proportion of missing data by variable, Original Dataset T0 and T2
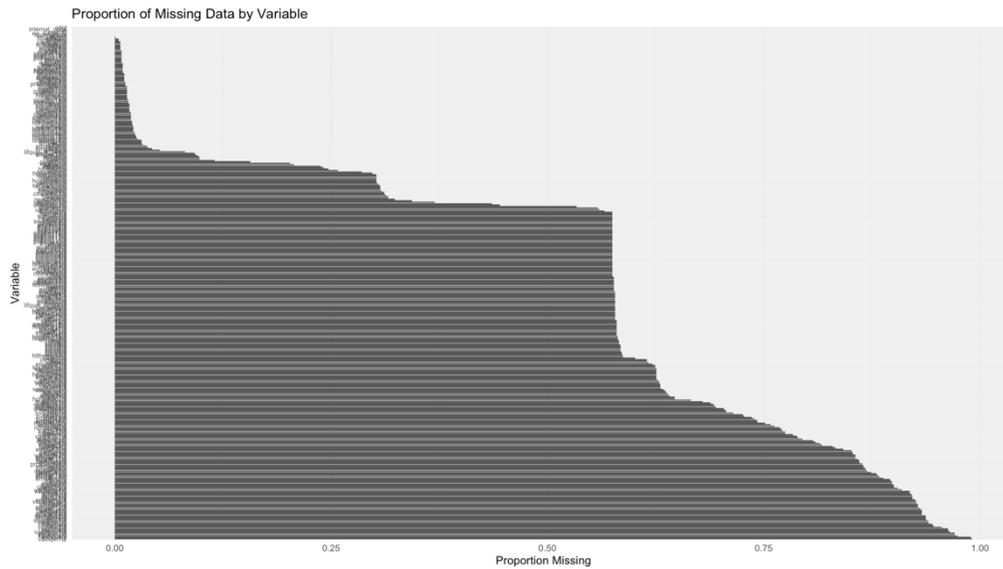
Fig 2. Proportion of Missing Data by Variable: This bar plot demonstrates the variability in missingness across variables, informing the choice of imputation strategies.

Figure 3. Missing Data Heatmap for 277 completers
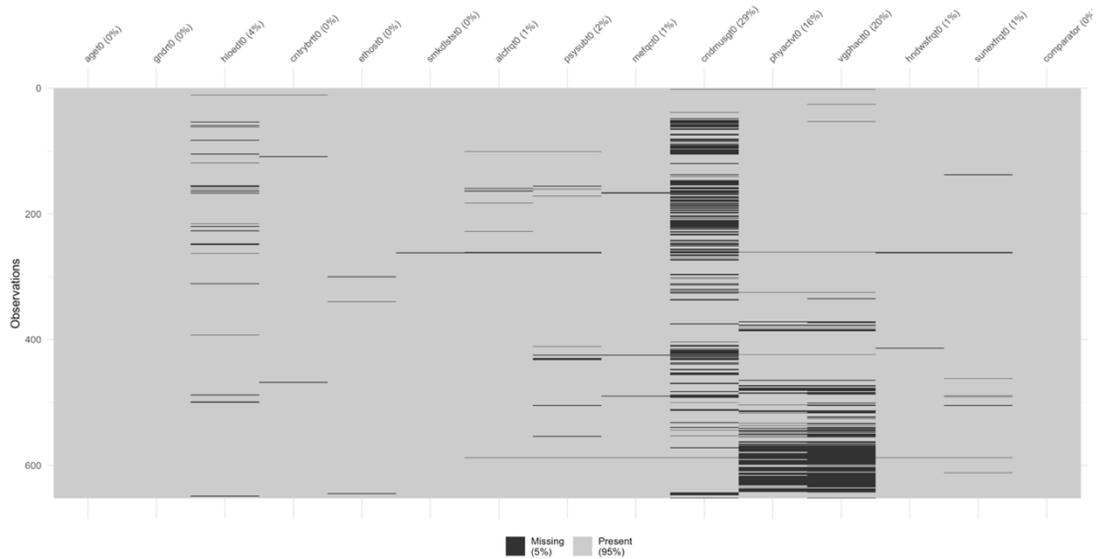
Fig 3. Missing Data Heatmap for Completers: This heatmap visualises the missingness across variables and participants, particularly those related to sexual health risks and physical activity.

3.2 Descriptive Statistics: Completers Only + T0 vs. T2 Comparative Analysis

This section focuses on the subgroup of 277 participants who completed both baseline and exit assessments. The median age was 50 years (IQR: 40–60), with 62% of participants being male, 38% female, and 71% of participants of European Union (EU) origin. At baseline, nearly 60% reported daily smoking, almost half never drank alcohol, and 80% never used psychoactive substances, though a minority reported regular alcohol or drug use. About three-quarters had two or three meals per day, while sexual risk behaviours were notable: 31% "rarely or never" used condoms, and only 20% reported consistent use. Most individuals were engaged in low physical activity levels, with a daily average of 10–30 minutes being common.

Missing data were most pronounced for vigorous/moderate physical activity and condom use (up to 35%), reflecting non-random patterns likely related to participant characteristics. Multiple imputations by chained equations addressed these gaps for variables with moderate/high missingness [25], while mode imputation or "Unknown" was used for others.

The table below presents the key variables at baseline (T0) and after the intervention (T2) among completers, along with the p-values and effect sizes for the statistical tests performed. Full details for all variables and categories assessed are provided in Appendix Table A1.

Table 1: Comparison Table for CANCERLESS Completers – Baseline (T0) vs Exit Assessments (T2)

Variable	Test	Statistic	P-Value	Effect Size	Change Direction	Interpretation of Change
Smoking Daily Status	McNemar's Test	2.083	0.149	N/A	Negative	No meaningful difference in smoking habits.
Alcohol Consumption Frequency	Wilcoxon Signed-Rank Test	1417.5	0.541	0.037	Negative	Alcohol consumption remained stable.
Psychoactive Substance Consumption	Wilcoxon Signed-Rank Test	138.0	0.718	0.004	Negative	No meaningful difference in psychoactive substance use.
Meal Frequency	Wilcoxon Signed-Rank Test	1102.0	0.983	0.029	Negative	Meal patterns did not change significantly.
Condom Use	Wilcoxon Signed-Rank Test	2084.5	0.024*	0.054	Negative	Increase in unprotected sexual intercourse
Physical Activity	Wilcoxon Signed-Rank Test	1907.0	0.061	0.050	Positive	Moderate physical activity increased slightly
Vigorous Physical Activity	Wilcoxon Signed-Rank Test	1027.0	0.00023**	0.027	Positive	Vigorous physical activity increased significantly.
Handwashing Frequency	Wilcoxon Signed-Rank Test	2032.0	0.443	0.053	Negative	Hygiene behaviours remained stable.
Sun Exposure Frequency	Wilcoxon Signed-Rank Test	2735.5	0.047*	0.071	Negative	Reduction in sun exposure.
ETHOS Homelessness Category Subgroup	Wilcoxon Signed-Rank Test	712.0	0.035*	0.018	Positive	Improvement in housing or socioeconomic conditions.

* p < 0.05; ** p < 0.001

Table 1: Comparison of key health behaviours and social factors for CANCERLESS completers at baseline (T0) and exit (T2). Statistically significant changes are indicated by p < 0.05 or p < 0.001.

Subgroup analyses showed nuanced effects. Among EU-origin completers, vigorous physical activity (p = 0.002, effect size = 0.034) and socioeconomic status (p = 0.028, effect size = 0.027) improved significantly, but sun exposure also increased (p = 0.046, effect size = 0.074), a negative outcome. Non-EU completers saw significant gains in both moderate (p = 0.008, effect size = 0.023) and vigorous activity (p = 0.021, effect size = 0.012) and a reduction in alcohol use (p =

0.020, effect size = 0.074); however, condom use decreased (p = 0.006, effect size = 0.099), raising public health concerns. The presence of statistically significant changes in certain variables enables advanced statistical modelling in subsequent analyses.

3.3 Advanced Statistical Analysis Results

To robustly examine the impact of the CANCERLESS intervention on modifiable cancer risk factors among completers, we applied repeated-measures ordinal logistic regression using cumulative link mixed models (CLMMs) to ordinal outcomes with statistical significance [27]. CLMMs are well-suited for this context, as they accommodate the ordinal nature of outcomes, account for within-subject correlations across time, and allow for both fixed effects (e.g., intervention, sociodemographic covariates) and random effects (e.g., individual variability). Missing data, particularly in sensitive behavioural domains, were addressed through multiple imputations [25], and the data were analysed in a long format with random intercepts for each participant.

3.3.1 Model Overview

The statistically significant variables, including condom use, physical activity, vigorous physical activity, sun exposure, and homelessness status (ETHOS subgroup), were identified as key variables. Covariates incorporated in the models were time (baseline vs. post-intervention), age, gender, highest educational level, EU status, smoking status, and legal status, as appropriate for each outcome. Subject ID was included as a random effect to capture individual variability. The models were fitted iteratively, beginning with simple time-only models to confirm convergence and then progressively incorporating additional covariates.

3.3.2 Results for Main Outcomes

The table below summarises the repeated-measures ordinal logistic regression (CLMM) results for key outcomes among completers, including main effect estimates, standard errors, p-values, and effect sizes where available.

Table 2: CLMM Models Results for CANCERLESS Completers – Baseline (T0) vs Exit Assessments (T2)

Outcome Variable	Predictor (Reference)	Estimate (β)	SE	p-value	Interpretation
Condom Use	Time (T2 vs. T0)	-0.420	0.197	0.032*	Decrease post-intervention
	Secondary education (none/basic)	1.803	0.615	0.003**	Higher use
	Tertiary education (none/basic)	1.485	0.796	0.063	Higher use (borderline)
	EU-status (non-EU vs. EU)	1.173	0.527	0.026*	Higher use
Physical Activity	Time (T2 vs. T0)	0.460	0.211	0.029*	Increase post-intervention
	EU-status (non-EU vs. EU)	-0.365	0.192	0.051	Lower non-EU improvement
Vigorous Activity	Time (T2 vs. T0)	0.750	0.242	0.0018**	Increase post-intervention
	Legal status (no docs vs. legal)	-2.201	0.583	<0.001**	Lower activity, no docs
Sun Exposure	Time (T2 vs. T0)	-0.320	0.184	0.080	Modest reduction
	Secondary education (none/basic)	1.640	0.384	<0.001**	More exposure
ETHOS Homelessness Category	Time (T2 vs. T0)	0.400	0.139	0.0042**	Improved housing
	Age (per year)	0.037	0.020	0.065	Older, more improvement
	Legal status (no docs vs. legal)	3.180	0.843	<0.001**	Much higher improvement
	Daily smoker (no vs. yes)	-1.110	0.540	0.041*	Less improvement, smokers

 * p < 0.05; ** p < 0.01

Table 2: Results of cumulative link mixed models (CLMM) comparing baseline (T0) and exit (T2) assessments for CANCERLESS completers. Shown are model estimates, standard errors, p-values, and interpretations for significant predictors of each outcome. Statistically significant associations are indicated by p < 0.05 and p < 0.01.

All models included a random intercept for subject. Model fit indices (AIC, log-likelihood) and diagnostics indicated robust performance, with substantial between-subject variability.

3.3.3 Key Predictors and Individual Variability

Across models, the strongest and most consistent effects were observed for the intervention's positive impact on physical and vigorous physical activity, as well as housing status. Education consistently emerged as a protective factor, especially for condom use and sun exposure. Non-EU status was a positive predictor for condom use but not for physical activity outcomes. Legal status was a strong determinant for vigorous activity and housing, with those lacking documents often experiencing greater change, though the direction (positive or negative) varied by outcome.

The random effects in each model were substantial, indicating high individual variability in response to the intervention. This suggests that additional, unmeasured factors—such as mental health, social support, or prior experiences—likely influence outcomes.

3.3.4 Model Diagnostics and Robustness

All main models demonstrated adequate fit, as evidenced by improved AIC and log-likelihood values with the addition of covariates and satisfactory convergence metrics (low maximum gradients and acceptable Hessian condition numbers). One model iteration failed to converge properly; however, the final selected models did not exhibit this issue, supporting the reliability of the inferential statistics. Sensitivity analyses, including models with alternative covariate configurations and imputation scenarios, confirmed the direction and statistical significance of the main findings.

3.4 Summary

In summary, the advanced statistical analyses revealed that the CANCERLESS intervention contributed to significant improvements in physical activity and housing status but was associated with a reduction in condom use frequency, a concerning trend for sexual health risk. The highest level of education, migration status, and legal status were important modifiers of these effects. The complexity of behavioural change among PEH may explain the substantial individual variability.

3.5 Subgroup Analyses and Effect Modification

To assess whether the effects of the CANCERLESS intervention varied by participant characteristics, subgroup analyses were performed by running separate models for key demographic and structural subgroups. Analyses focused on the region of birth (EU vs. non-EU), education, and legal status. Of the 277 completers, 71.1% were from the European Union (EU), and 28.9% were from non-EU countries. The table below summarises the main statistically significant findings by subgroup.

Table 3: Subgroup Analyses Results – Comparison between T0 and T2

Subgroup	Variable	Test	Statistic	p-value	Effect Size	Change Direction	Note
EU-origin	Vigorous physical activity	Wilcoxon Signed-Rank Test	655.0	0.002**	0.034	Positive	Significant increase in vigorous physical activity.
EU-origin	ETHOS Homelessness Category	Wilcoxon Signed-Rank Test	517.0	0.028*	0.027	Positive	Significant improvement in housing or socioeconomic conditions.
EU-origin	Sun exposure	Wilcoxon Signed-Rank Test	1446.5	0.046*	0.074	Positive	Significant increase in sun exposure frequency (negative outcome).
Non-EU	Physical activity	Wilcoxon Signed-Rank Test	73.5	0.008**	0.023	Positive	Significant increase in physical activity.
Non-EU	Vigorous physical activity	Wilcoxon Signed-Rank Test	39.0	0.021*	0.012	Positive	Significant increase in vigorous physical activity.
Non-EU	Alcohol consumption	Wilcoxon Signed-Rank Test	241.0	0.020*	0.074	Negative	Significant decrease in alcohol consumption frequency.
Non-EU	Condom use	Wilcoxon Signed-Rank Test	321.5	0.006**	0.099	Negative	Significant decrease in condom use (negative outcome).

* p < 0.05; ** p < 0.01

Table 3: Subgroup analyses comparing baseline (T0) and exit (T2) for key outcomes among EU-origin and non-EU participants. Statistically significant changes are indicated by p < 0.05 and p < 0.01.

These results suggest that the effects of intervention are not uniform across subgroups. Variation in outcomes, especially for sexual health and substance use, indicates that more tailored, responsive approaches are needed to address the complex needs of people experiencing homelessness.

3.6 Sensitivity Analyses and Limitations in Results

To assess the robustness of our results, we conducted analyses both before and after multiple imputations for missing data, given that variables such as vigorous and moderate physical activity had up to 35% missing values [25]. Results across imputed and observed datasets were largely consistent, suggesting that missing data did not substantially bias the main findings. However, the pattern of missingness appeared partially systematic and likely missing at random, which may still introduce some bias.

Other limitations include the non-randomised, non-controlled study design, which limits causal inference [18]. Self-reported measures may be subject to recall and social desirability bias, particularly regarding sensitive behaviours like substance use and sexual activity. The sample of 277 completers could also differ systematically from non-completers, potentially affecting generalisability. Additionally, sample-size-constrained subgroup analyses may have limited power to detect minor effects. Despite these caveats, the main findings appear robust but should be interpreted cautiously and validated in future controlled studies.

CHAPTER 4: Discussion

4.1 Overview and Main Findings

This research study examined the effect of the CANCERLESS intervention on modifiable cancer risk factors among people experiencing homelessness (PEH) across four European countries. The central research question addressed whether participation in the intervention would be associated with statistically significant reductions in risk behaviours, including smoking, alcohol use, inconsistent diet habits, low physical activity, and risky sexual behaviours. We hypothesised that from baseline (T0) to exit (T2), the intervention would lead to meaningful changes in these modifiable cancer risk factors as reported via self-report questionnaires.

Among the 277 participants who completed both assessments, the most consistent and significant improvements were observed in physical activity and housing status. For example, the odds of reporting higher levels of vigorous physical activity increased significantly after the intervention (estimate = 0.75, p = 0.0018), as did overall physical activity (estimate = 0.46, p = 0.029). Housing stability, measured by a positive transition in the ETHOS categories, also improved significantly (estimate = 0.40, p = 0.0042), suggesting that the intervention may positively impact this important social determinant of health. These changes are promising, especially considering the established links between physical inactivity, housing instability, and cancer prevalence [28,13]. Notably, these findings highlight not only improvements in health behaviours and housing status but also the potential for enhanced access to interconnected support systems such as social care.

However, not all variables demonstrated positive variation. Some important cancer risk factors, such as frequency of condom use, decreased significantly post-intervention (estimate = -0.420, p = 0.032), suggesting an increase in reports of unprotected sexual intercourse. It is also possible, however, that after a period of ongoing contact with navigators, participants felt more comfortable disclosing sensitive behaviours, leading to an "artificial" increase in reported risk. This underscores the complexity of influencing sexual health behaviours among priority populations like PEH [29]. Other risk behaviours, including smoking, alcohol use, and dietary patterns, did not show statistically significant changes, with small effect sizes and p-values above 0.05.

Effect modification analyses revealed that certain sociodemographic factors played a significant role in the outcome of the intervention. For instance, education level emerged as a strong positive predictor for improved condom use and sun exposure behaviours, while non-EU status was associated with an increase in reported condom use. Legal status and age influenced specific models (such as housing stability and physical activity), though not always consistently. These

patterns align with prior research underscoring the importance of structural and social determinants in shaping healthy lifestyle behaviours among PEH [30,31].

In summary, the CANCERLESS intervention demonstrated significant positive effects on physical activity and housing stability (ETHOS subgroup), but did not yield a uniform positive impact across all variables of interest. The reported decrease in condom use and the lack of significant changes in other modifiable cancer risk factors indicate that additional or modified strategies may be needed to achieve sustainable behavioural change. Furthermore, the substantial dropout rate highlights the need for enhanced mechanisms to ensure adherence to interventions and healthcare initiatives targeting this priority population. Nonetheless, these findings provide valuable context for interpreting subsequent research in navigation models, policy implications, limitations, and future research into the health of PEH.

4.2 Interpretation of Results

The significant improvements observed in physical activity and housing stability among the completers of the CANCERLESS intervention may have meaningful public health implications for people experiencing homelessness (PEH), a group known to be at higher risk for cancer and chronic diseases [13]. Physical activity is closely linked to reduced cardiovascular and cancer risk, and the observed increases in both physical activity and housing stability are particularly valuable considering the barriers to healthy behaviours that PEH commonly face, such as unstable daily routines and limited access to safe spaces [7]. The improvement in housing situation also underscores the importance of integrated and multifaceted support models for priority populations. Stable housing is critical not only to sustaining positive health behaviours and accessing preventive care, but also to enhanced access to one system (e.g., healthcare) may also facilitate improved access to others, such as social care and support.

However, the intervention did not have a uniformly positive effect across all modifiable cancer risk behaviours considered in this study. The most notable outcome is a decline in condom use frequency, indicating an increase in reported unprotected sexual intercourse in an already vulnerable population. It is worth considering that this result might be influenced by increased openness and trust built with navigators over time, leading participants to disclose sensitive behaviours more honestly, rather than reflecting an actual increase in risk. Reporting bias could play a role, with participants possibly having overreported condom use at baseline due to social desirability or underreporting at follow-up due to greater comfort with the research team. Either

way, this finding highlights the need for more integrated and intensive approaches to sexual health within interventions for PEH. It suggests that the focus of the CANCERLESS intervention may not have been directly aimed at safer sex behaviours.

Analysis of effect modification showed that education level, migration status, and legal status significantly influenced intervention outcomes. For instance, higher education levels were associated with improved condom use (secondary education: estimate = 1.803, p = 0.003; tertiary: estimate = 1.485, p = 0.063) and higher sun exposure (estimate = 1.64, p < 0.001), aligning with prior literature indicating that education enhances health literacy and the adoption of protective behaviours [7]. In addition, non-EU participants exhibited greater improvements in condom use (estimate = 1.173, p = 0.026). Even though this can be due to different cultural norms or access to healthcare prevention services, social desirability bias may have played a role in this finding. Non-EU participants may have felt that they needed to show more desirable behaviours, even if they are not completely accurate. Legal status also had an important role in changes in housing stability (estimate = 3.18, p < 0.001) and vigorous physical activity, which may be related to extra access to social support programs not necessarily focused on health. Finally, daily smoking status was negatively associated with housing improvement (estimate = -1.11, p = 0.041), possibly indicating that individuals with persistent risk behaviours face additional barriers to improving their overall health and living conditions [14].

Broader literature shows some consistencies and contrasts with the findings of this study. Navigation-based interventions have successfully improved housing and some health behaviours among PEH [15]. However, these interventions may struggle to produce sustained changes in substance use or sexual health [11]. Our study's lack of changes in substance use variables and meal frequency (all p > 0.05) aligns with these previously observed patterns. Time-limited models may need to be supplemented by ongoing, multilevel support with collaboration of multiple actors, including the public sector and civil society. Nevertheless, our sample's marked and consistent improvement of physical activity levels and homelessness status is encouraging. It provides meaningful evidence that even within a challenging context such as the PEH, positive change can be attained with innovative and holistic interventions to address basic needs alongside health risk behaviours.

In conclusion, the CANCERLESS intervention improved physical activity levels and homelessness status among PEH participants who completed it. The effect sizes and significance levels support genuine behavioural change that aligns with previous literature and research. However, the worsening of some of the modifiable risk factors and the lack of change in some

others highlights the limitations of healthcare interventions. This also underscores the need for more tailored and sustained interventions for the diverse needs of PEH.

4.3 Implications for Policy and Public Health Practice

The findings of the study highlight the urgent need for tailored cancer prevention interventions for priority populations such as people experiencing homelessness (PEH). Multicomponent navigation models can yield significant improvements in modifiable cancer risk factors and social determinants of health. Commitments to health equity and the right to health for all are substantially reinforced by including priority populations. In addition, these interventions increase visibility and inclusion of PEH in cancer prevention strategies, ultimately leading to better health outcomes.

Despite this health intervention's innovative and promising nature, the mixed outcomes observed in this study highlight key points for improvement. The decline in condom use frequency highlights the need for stronger and targeted sexual health education within navigation models. Culturally sensitive materials and access to prevention resources can be a way of improving the outcomes in sexual risk behaviours. However, the participation of the public healthcare system and public policy programmes is necessary to achieve sustainable, empowering change. Since education levels and legal status also modified the intervention effects, future programmes should address structural barriers for populations with less access to education while including national education systems reforms and cultural support initiatives as a pivotal point in the design of such programmes. The positive outcome in homeless status among participants lacking legal documentation indicates that navigation services could benefit from a joint work with social and immigration support services, which can, in consequence, improve their access to social housing, education and healthcare services for PEH.

In terms of public policy, these results call for a consistent inclusion of priority populations such as PEH in national and regional cancer prevention strategies. Health systems should consider investing in sustained, nationwide navigation models focused on cancer and different prevention strategies for communicable and non-communicable diseases. Despite different healthcare systems and policies supporting PEH, the model's apparent effectiveness across multiple European contexts indicates that similar models could be scaled and adapted in other countries with comparable contexts. Nevertheless, the transferability and replicability of this model may be challenging to ensure due to the statistical limitations and the substantial loss of follow-up. Close

attention to local contexts, stakeholder engagement and ongoing evaluation can provide a strong starting point for future interventions and meaningful change.

4.5 Study Limitations

While the current study provides relevant and meaningful insights into the effects of the CANCERLESS intervention among PEH who completed the intervention time, limitations should be acknowledged to weigh the real impact of the results.

A major limitation is the substantial rate of attrition observed due to loss to follow-up between baseline (T0) and exit (T2). To address this, a "completers-only" analysis was performed rather than employing imputation or other missing data approaches, in order to preserve methodological integrity and ensure valid inferences. However, this approach introduces the potential for selection bias, as individuals who remain engaged may differ systematically from those who drop out—potentially in terms of motivation, stability, or social and health conditions [32]. Consequently, the reported intervention effects may be overestimated and may not reflect the actual experience of all PEHs enrolled in the programme. It is also important to note that limited generalizability is not only the result of attrition, but was always an inherent issue due to the sampling strategy used in the study.

Using a single-arm, non-randomised design can also limit the generalizability of the findings. The lack of a control group makes it difficult to attribute the observed changes only to the intervention since other external factors may have influenced the outcomes [33]. The lack of randomisation also means that unmeasured confounders such as mental health status, social support or prior medical history could have affected the results. Generalisability remains limited primarily due to the sampling approach, regardless of sample size or attrition.

Measurement limitations should also be considered. The modifiable cancer risk factors were measured with self-report questionnaires, which were susceptible to recall and social desirability bias. While multiple imputations were employed to address missing data, such a method relies on assumptions that might be difficult to prove in a highly mobile population such as PEH [34]. Besides, using ordinal categories for key outcomes may mask subtle changes and make interpretability challenging.

Finally, the statistical power of advanced and subgroup analyses was limited by the reduced sample size, a consequence of loss to follow-up. Small numbers in subgroups (such as those defined by education level and legal status) may have resulted in wide confidence intervals and increased Type II error. These limitations constrain the models' ability to detect small but potentially meaningful effects of the intervention.

In summary, while the analytical approach, use of CLMM, and multiple imputation strengthened internal validity and provided meaningful information for the project, the study's limitations reinforce the importance of controlled intervention designs, especially those with a focus on retention strategies and broader measures of behavioural change in highly mobile and vulnerable populations.

4.6 Strengths of the Study

While the expected limitations posed by a highly mobile group such as PEH present challenges to this study, several strengths contribute meaningfully to the evidence base for cancer prevention among PEH. First, the CANCERLESS intervention represents a novel and holistic approach to improving health outcomes for an often-ignored priority population using tailored behavioural support in different countries and contexts. This in itself should make the study's findings valuable as they help enrich the multiple gaps in the literature and help shape future interventions. Advanced statistical methods such as CLMM [27] and multiple imputation [25] allowed for a robust analysis of ordinal outcomes. They may indicate a first step in approaching real-world databases with significant attrition levels. The subgroup analyses further enhanced the depth of our findings, underscoring how social determinants of health are crucial to determining a healthcare intervention's success or failure.

The literature regarding cancer prevention and navigation models for PEH is scarce. This study also fills in the health equity and policy gaps by focusing on PEH. To help a priority and often invisible population, it is essential to continue building valuable insights into their healthcare habits, barriers, and other common epidemiological interventions that may easily overlook their vulnerability. The strengths of this study highlight the value and originality of the CANCERLESS intervention as an inclusive and empowering model that can inform the development of effective public health strategies for priority populations.

CHAPTER 5: Conclusion

5.1 Synthesis of Key Findings

The primary aim of this thesis was to investigate the effect of the CANCERLESS intervention on modifiable cancer risk factors among people experiencing homelessness (PEH) in four pilot European countries. The central research question asked whether participation in this navigation-based intervention would be associated with improvements in behaviours that increase cancer risk, as measured from baseline (T0) to exit (T2). It was hypothesised that the intervention would lead to reductions in behaviours such as tobacco and alcohol use while promoting physical activity, healthy dietary habits, and safer sexual health practices. The CANCERLESS intervention integrated health navigation, tailored behavioural support, and access to social and legal services, aiming to address the complex and competing needs of a population often excluded from conventional public health programmes.

Using both non-parametric tests and repeated-measures ordinal logistic regression, the evaluation of the 277 participants who completed the CANCERLESS intervention revealed the following findings. Vigorous physical activity showed the most robust improvement, with the odds of higher activity post-intervention increasing significantly (estimate = 0.75, p = 0.0018). Homelessness status also improved, with a significant positive shift (p = 0.0042), especially among those without legal documents. However, the intervention was also associated with a significant decline in condom use (estimate = -0.42, p = 0.032), with higher levels of education and non-EU status predicting better outcomes. Changes in other behaviours, such as smoking, alcohol use, and meal frequency, were not statistically significant, although non-EU participants reduced alcohol consumption (p = 0.020). Sun exposure also increased among non-EU participants (p = 0.046).

In a broader perspective, these findings align with the results of previous studies. Navigation-based interventions may improve physical activity and homelessness status, but they may not be sufficient to change more complex risk behaviours such as substance use and sexual health practices. Education level and legal status emerged as important covariates influencing how participants responded to the intervention, highlighting the need for integrated care, where social, educational, and health systems must work together with a higher degree of integration to effectively address the needs of people experiencing homelessness (PEH).

The positive outcomes in physical activity and homelessness status among CANCERLESS completers show meaningful progress for cancer prevention in this priority population. The links

between physical activity and a reduction in cardiovascular disease and cancer risk are notable, especially considering the daily challenges faced by people with epilepsy (PEH). Similarly, improvements in housing status demonstrate the added value of this intervention, as stable housing is a key determinant of favourable health outcomes. However, the adverse effects on some variables—such as the decline in condom use—raise concerns about increased unprotected sex in an already vulnerable group. Unaddressed structural, cultural, and social factors, well beyond this study's scope, may underlie these challenges, and future interventions should place greater emphasis on sexual health. The participants' education level and legal status should also be considered, not just for this initiative but for other cancer risk prevention efforts as well.

5.2 Recommendations

Public health practitioners and policymakers should consider adopting navigation-based models that address behavioural and structural determinants of health to maximise the impact of cancer prevention efforts among people experiencing homelessness (PEH). Interventions such as CANCERLESS, which combines physical activity promotion, housing support, and legal or social aid, show promise in improving outcomes that simpler interventions may fail to address. The delivery of services should be flexible and tailored, with a special emphasis on education, migration and legal support services.

It is essential to include PEH in cancer prevention strategies and to allocate sufficient resources to this priority group. The collaboration between the public sector and multilateral organisations, as well as the co-design of interventions with PEH, may help enhance uptake and adherence to these initiatives. It is recommended that future interventions prioritise system integration—bringing together health, social, and educational services to provide a holistic approach that reflects the complex realities of PEH.

Future research should explore the long-term sustainability and scalability of integrated health navigation models such as CANCERLESS in other contexts and with other vulnerable demographic groups. Process evaluations and qualitative research are needed to understand high dropout rates and the limited improvements in sexual health and substance use. The perspectives of participants, especially those who did not complete the intervention, should be given special attention to identifying additional factors that may influence intervention effectiveness and inform the design of more inclusive and responsive programmes.

The CANCERLESS intervention has demonstrated that historically marginalised groups can have a better opportunity to avoid being left behind through collaboration, innovation, and co-creation of healthcare initiatives. People experiencing homelessness already face many challenges, and in the middle of the uncertainty, a preventable disease such as cancer should not be one more barrier.

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List of Appendices

Appendix 1: Comparison Table for CANCERLESS Completers – Baseline (T0) vs Exit Assessments (T2)

Variable	Category	T0 n (%)	T2 n (%)	Change (T2–T0)	Test (statistic)	p-value	Effect size
Smoking Daily Status	Daily smoker	164 (59.2%)	158 (57.0%)	-2.2%	McNemar's Test (2.083)	0.149	–
	Non daily-smoker	113 (40.8%)	119 (43.0%)	+2.2%			
Alcohol Consumption Frequency	Never	131 (47.3%)	140 (50.5%)	+3.2%	Wilcoxon Signed-Rank Test (1417.5)	0.541	0.037
	Monthly or less	57 (20.6%)	50 (18.1%)	-2.5%			
	2–4 times per month	46 (16.6%)	43 (15.5%)	-1.1%			
	2–3 times per week	23 (8.3%)	22 (7.9%)	-0.4%			
	4+ times per week	20 (7.2%)	22 (7.9%)	+0.7%			
Psychoactive Substance Use	Never	225 (81.2%)	225 (81.2%)	0.0%	Wilcoxon Signed-Rank Test (138.0)	0.718	0.004
	Monthly or less	9 (3.2%)	10 (3.6%)	+0.4%			
	2–4 times per month	11 (4.0%)	10 (3.6%)	-0.4%			
	2–3 times per week	8 (2.9%)	11 (4.0%)	+1.1%			
	4+ times per week	24 (8.7%)	21 (7.6%)	-1.1%			
Meal Frequency	None	1 (0.4%)	0 (0.0%)	-0.4%	Wilcoxon Signed-Rank Test (1102.0)	0.983	0.029
	One	48 (17.3%)	43 (15.5%)	-1.8%			
	Two	112 (40.4%)	127 (45.8%)	+5.4%			
	Three	97 (35.0%)	82 (29.6%)	-5.4%			
	Four or more	19 (6.9%)	25 (9.0%)	+2.1%			

Condom Use	Always	73 (26.4%)	79 (28.5%)	+2.1%	Wilcoxon Signed-Rank Test (2084.5)	0.024*	0.054
	Most of the time	50 (18.1%)	59 (21.3%)	+3.2%			
	About half the time	26 (9.4%)	26 (9.4%)	0.0%			
	Less than half the time	20 (7.2%)	21 (7.6%)	+0.4%			
	Rarely or never	108 (39.0%)	92 (33.2%)	-5.8%			
Physical Activity	10–30 min/day	180 (65.0%)	164 (59.2%)	-5.8%	Wilcoxon Signed-Rank Test (1907.0)	0.061	0.050
	30–60 min/day	22 (7.9%)	42 (15.2%)	+7.3%			
	1–2 hours/day	49 (17.7%)	30 (10.8%)	-6.9%			
	2–3 hours/day	4 (1.4%)	7 (2.5%)	+1.1%			
	3+ hours/day	22 (7.9%)	34 (12.3%)	+4.4%			
Vigorous Physical Activity	10–30 min/day	211 (76.2%)	196 (70.8%)	-5.4%	Wilcoxon Signed-Rank Test (1027.0)	0.00023**	0.027
	30–60 min/day	25 (9.0%)	18 (6.5%)	-2.5%			
	1–2 hours/day	22 (7.9%)	26 (9.4%)	+1.5%			
	2–3 hours/day	8 (2.9%)	1 (0.4%)	-2.5%			
	3+ hours/day	11 (4.0%)	36 (13.0%)	+9.0%			
Handwashing Frequency	Never	6 (2.2%)	6 (2.2%)	0.0%	Wilcoxon Signed-Rank Test (2032.0)	0.443	–
	Once	28 (10.1%)	38 (13.7%)	+3.6%			
	2–4 times	148 (53.4%)	136 (49.1%)	-4.3%			
	5 or more	95 (34.3%)	97 (35.0%)	+0.7%			
Sun Exposure Frequency	Never	22 (7.9%)	33 (11.9%)	+4.0%	Wilcoxon Signed-Rank Test (2735.5)	0.047*	0.071
	Rarely	82 (29.6%)	80 (28.9%)	-0.7%			

	Sometimes	89 (32.1%)	88 (31.8%)	-0.3%			
	Often	84 (30.3%)	76 (27.4%)	-2.9%			
ETHOS Homelessnes s Category	Roofless	96 (34.7%)	78 (28.2%)	-6.5%	Wilcoxon Signed-Rank Test (712.0)	0.035*	0.018
	Houseless	59 (21.3%)	77 (27.8%)	+6.5%			
	Insecure	94 (33.9%)	84 (30.3%)	-3.6%			
	Inadequate	28 (10.1%)	38 (13.7%)	+3.6%			

* p < 0.05; ** p < 0.001

Appendix 1: Distribution and change in key health behaviours and social factors among CANCERLESS completers at baseline (T0) and exit (T2). Statistically significant changes are indicated by p < 0.05 and p < 0.001.

Appendix 2: Ethical approval from the University of Sheffield, with application reference number 067025

Juan Esteban Guzman Benitez
Registration number: 230137556
School of Medicine and Population Health
Programme: MPH European Public Health

Dear Juan Esteban

PROJECT TITLE: What is the effect of the CANCERLESS intervention on modifiable cancer risk factors and screening participation rates among PEH in 4 pilot European countries?
APPLICATION: Reference Number 067025

This letter confirms that you have signed a University Research Ethics Committee-approved self-declaration to confirm that your research will involve only existing research, clinical or other data that has been robustly anonymised. You have judged it to be unlikely that this project would cause offence to those who originally provided the data, should they become aware of it.

As such, on behalf of the University Research Ethics Committee, I can confirm that your project can go ahead on the basis of this self-declaration.

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since full ethical review may be required.

Yours sincerely

Charlotte Cole
Departmental Ethics Administrator