



## Effectiveness of public health measures in reducing the incidence and lethality of cancer: A systematic review and meta-analysis

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World Journal of Advanced Research and Reviews, 2024, 23(02), 371–393

Publication history: Received on 23 June 2024; revised on 02 August 2024; accepted on 04 August 2024

Article DOI: <https://doi.org/10.30574/wjarr.2024.23.2.2354>

### Abstract

Cancer constitutes a real public health problem, and its burden is expected to increase national health systems. The future burden is likely to be much greater due to the increasing prevalence of factors that increase risk, such as smoking, alcoholism, unhealthy diet, physical inactivity, sedentary lifestyle, etc.

The objective of this work is to evaluate, through a systematic review, the impact of public health measures on the incidence and lethality of cancers.

51 studies met the inclusion criteria in this review. High adherence to established public health cancer control guidelines for nutrition and physical activity was consistently and significantly associated with reductions of 10% to 61% in overall cancer incidence colorectal cancer in men and women (27%-52%), the incidence of breast cancer (19-60%) and prostate cancer (5 -10%), Significant reductions in the incidence and lung cancer mortality after tobacco control measures. The human papilloma vaccine has shown excellent safety and close to 100% effectiveness in preventing persistent infections and precancerous lesions of the cervix due to types 16 and 18.

Through this study, we were able to know the influence of public health measures on the incidence and lethality of cancers.

**Keywords:** Colorectal cancer; Lung cancer; Cervical cancer; Breast cancer; Incidence; Smoking; Vaccination; Nutrition; Public health.

### 1. Introduction

Cancer is one of the most feared diseases of the twentieth century, and its incidence has been steadily increasing in recent years. The latter is a real public health problem. In addition, cancer is the second leading cause of death after cardiovascular disease (1).

According to the World Health Organization (WHO), 18.1 million new cases of cancer were diagnosed worldwide of all types, and caused nearly 10 million deaths in 2020, and about one-third are due to continued exposure to risk factors (2).

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Since 2011, WHO has been calling on all Member States to better define their programs to combat this disease, in order to offset the significant economic burden of cancer in all countries (3).

Cancer control strategies include planning, reducing non-behavioral factors such as environmental and infectious risks in all countries, as well as advances in cancer treatment and effective health systems in wealthier countries (4).

By 2040, the global burden is expected to reach 27.5 million new cancer cases and 16.3 million cancer deaths (5). Cancers linked to certain factors, such as smoking, alcoholism, an unbalanced diet, physical inactivity, a sedentary lifestyle and a decrease in the number of pregnancies, are already on the rise in countries in economic and epidemiological transition, hence the importance of developing control plans based on a global approach that includes these different risk factors (6).

Indeed, more than 50% of cancers are preventable by adopting primary prevention measures for the benefit of the general population to support an environment that minimizes exposure to risk factors.

As part of cancer control strategies, several public health measures have been carried out and have reduced the impact on the epidemiology of cancers, including lung, prostate, colorectal, breast and cervical cancers (7).

The knowledge of these measures by general practitioners will allow these health professionals to actively participate in the fight against this burden by insisting on the measures that have shown a positive impact on the incidence and survival of the various cancers (8).

However, there are no comprehensive estimates of cancer risk factors for many countries, leaving a significant gap as countries develop and update their control plans (9). It has been identified that a broader and coordinated public health approach, integrating harm reduction, early detection and post-diagnosis care, may be needed to address this condition (10).

The objective of our work is to evaluate, through a systematic review, the impact of public health measures on the incidence and lethality of major cancers.

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## **2. Material and methods**

The methodology for this study is structured around a PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), focusing on the evaluation and comparison the effectiveness of measures of public health to fight cancer. This study concerns the main cancers (lung, prostate, colorectal, breast and cervix).

### **2.1. Research question**

The research question was formulated using the acronym "PICO" as follows:

Are public health measures and tools effective on cancers in a diagnosed adult population?

### **2.2. Data Sources & Search Strategy**

Peer-reviewed academic journals, conference proceedings, and reliable digital libraries are the main sources of data used in this research. To find pertinent literature, important databases like PubMed, Scopus, Web of Science, and Google Scholar are used.

First, to find out which cancers were most often studied in the literature, we conducted a first search on Google Scholar using these 2 research equations ("public health" AND "cancer").

The most studied cancers were selected, then for each cancer we chose the most studied public health interventions.

From this search on Google Scholar, Medline (PubMed), ScienceDirect and Web of Science, we have selected the keywords MeSH and CisMeF.

### 2.3. Inclusion and Exclusion Criteria for Relevant Literature

#### 2.3.1. Inclusion Criteria

- Articles in English or French published between 1998 and 2023.
- Studies focusing on the impact of different public health measures on the cancer incidence and lethality.
- Population target: adult population diagnosed with cancer (Breast, lung, prostate and colorectal and cervix)
- Types of study: observational, prospective or retrospective type, (Cohort, Control case).
- Articles providing empirical data, theoretical analyses, or comprehensive reviews.

#### 2.3.2. Exclusion Criteria

- Articles not focusing on the impact of public health measures.
- Article treating cancers for pediatric population.
- Duplicate studies among clinical trials and observational studies.
- Outdated research or literature published before 1998.
- Articles that are either fully or partially hidden behind paywalls.

### 2.4. Selection Criteria

There are two screening stages in the selection process. In order to determine relevance based on the inclusion and exclusion criteria, titles and abstracts are first reviewed. Full-text articles are then scrutinized for in-depth analysis. The selection places particular emphasis on studies that provide important new information about how various public health measures affect the incidence and mortality of cancer.

A standard grid developed for study allowed the extraction of qualitative and quantitative data from the chosen articles.

### 2.5. Data Analysis

The results were grouped according to the design of our study and summarized in tabular form.

Statistical data were extracted and presented as proportions (incidence, mortality and survival) and association measures (OR) with their 95% confidence interval and p-value.

Mean observed effects and overall effects were expressed as OR and absolute risk reduction (AR). They were presented in the form of a graph in the forest. The random effects model was chosen to support the diversity of individual studies.

The heterogeneity of the studies was tested using the Cochran Q test and the  $I^2$ .

The data collected and the statistical analysis of the articles included were the subject of a computer input of texts and graphics using Microsoft Word and Microsoft Excel software.

The quality of the selected studies was evaluated using the grids presented by the JBI (Joanna Briggs Institute) Manual for Evidence Synthesis.

JAMOVI 2.3.21 software was used for data management and statistical analysis.

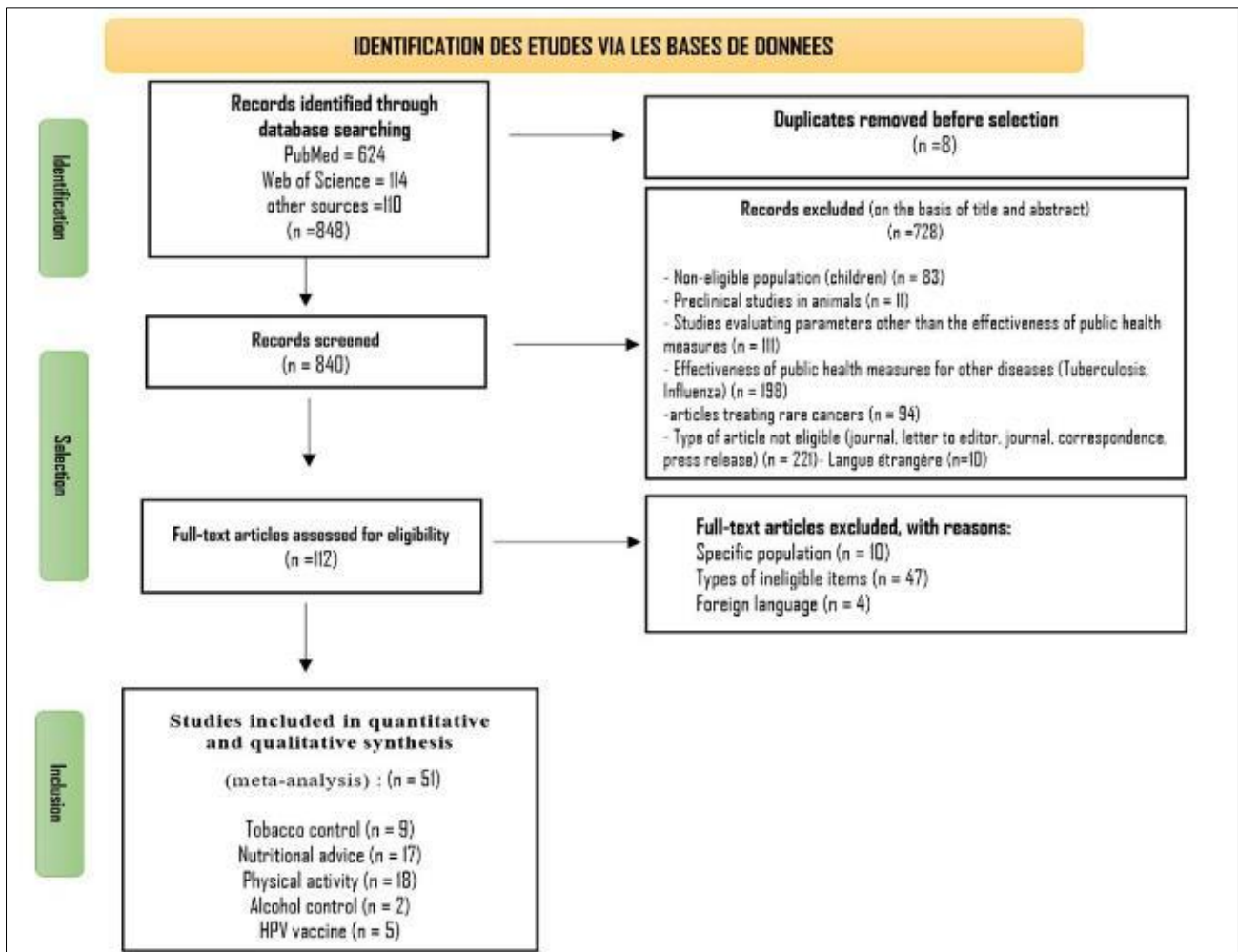
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## 3. Results

### 3.1. Selection of studies

Our search of the various databases resulted, after removal of duplicates, in 1048 publications, the initial selection on the basis of titles and summaries made it possible to retain 51. Subsequently, 19 studies were excluded for non-compliance with the inclusion criteria, resulting in studies that met these criteria and were included in our systematic review.

This study focused on the 5 public health measures for the fight against the incidence and lethality of cancers, articles on physical activity were the most prevalent (n = 18), followed by articles on nutritional advice (n = 17), articles on tobacco control (n = 9), vaccination against HPV (n = 5) and finally articles on the fight against alcohol (n = 2) (Figure 1).



**Figure 1** Articles search, screening and selection process

### 3.2. Results of studies

#### 3.2.1. Tobacco control:

For tobacco control, 9 prospective study articles, totaling 656,706 participants were included in this review. The cancer studied was lung cancer.

The main endpoint studied was cancer mortality in 5 articles among the 9 selected with a risk of death in patients benefiting from a tobacco control measure between HR = 0.6 and HR = 0.8, suggesting a preventive fraction of 20% to 30%.

In the 4 articles, the criterion of judgment was to evaluate the incidence of cancer after the implementation of tobacco control measures, with rates varying between 13.3% and 49%. (Table 1).

#### 3.2.2. Nutritional diet:

For the Nutritional advise in the fight against cancer, we selected 17 articles of which 16 were prospective studies. In these articles, the total study population was 472,499 participants.

The most studied cancers were breast cancer (6/17) and prostate cancer (3/17) and colorectal cancer (3/17).

The most studied cancers were breast cancer (6/17) and prostate cancer (3/17) and colorectal cancer (3/17).

The primary endpoint was cancer incidence in patients on a balanced (Mediterranean) diet in 4 of the 17 selected articles. In these studies, a variable odd ratio (OR) of between 0.59 and 0.79 was observed, suggesting a preventive

fraction of 21% to 41%. Similarly, in 4 of the 17 articles treating the incidence of cancer in patients on an unbalanced (Western) diet, an odds ratio (OR) varying between 2.45 and 53.2 was associated.

In 5 articles, the criterion I judgment studied was the overall survival with a risk of death in patients following a balanced diet (Mediterranean) between 0.62 and 0.81, suggesting a preventive fraction between 19% and 38%. (Table 2).

### 3.2.3. Physical activity:

Regarding the promotion of physical activity, we have retained 17 prospective study articles and one retrospective study article. In these articles, the total study population was 1,647,114 participants.

The most studied cancers were prostate cancer (6/18), lung cancer (5/18) and breast cancer (4/18).

The primary endpoint studied in 13 of the 18 selected articles was cancer incidence. In individuals regularly engaged in physical activity, it was associated with an odds ratio (OR) ranging from 0.24 to 0.77, suggesting a preventive fraction of between 23% and 76%. In individuals not regularly engaged in physical activity, it was associated with an odds ratio (OR) ranging from 1.21 to 1.57.

Five papers studied the outcome of mortality in patients engaged in physical activity, with a Hazard Ratio (HR) between 0.63 and 0.8. (Table 3).

### 3.2.4. HPV vaccine:

For the human papillomavirus vaccine, we selected 5 prospective study articles. In these articles, the total study population was 1,647,114 participants.

The cancer studied was cervical cancer.

The primary endpoint studied in four of the five articles was the incidence of cancer in vaccinated women. It was associated with an odds ratio (OR) between 0.05 and 0.85, suggesting a preventive fraction between 15% and 95%. (Table 4).

### 3.2.5. Alcohol:

For the fight against alcoholism, we have selected 2 articles of prospective studies. In these articles, the populations studied are those of Australia and Denmark.

The cancers studied were breast cancer, lung cancer and colorectal cancer.

The main endpoint studied was the incidence of cancer in patients benefiting from alcohol control measures in both articles. It was associated with an odds ratio (OR) between 0.05 and 0.18, suggesting a preventive fraction between 82% and 95%. (Table 5).

## 3.3. Effect of public health measures against cancer (Meta-analysis)

The analytical study was stratified by the type of public health intervention studied. Our results suggest that public health prevention measures have a positive impact on cancer epidemiology. Indeed, an absolute risk reduction (RAR) is observed in all patients who have benefited from preventive measures. Physical activity and HPV vaccination have the greatest effect.

However, heterogeneity analysis showed a high variability between studies with an  $I^2$  ranging from 90.51% to 99%. This heterogeneity persisted even in subgroup analyses (Figure 2).

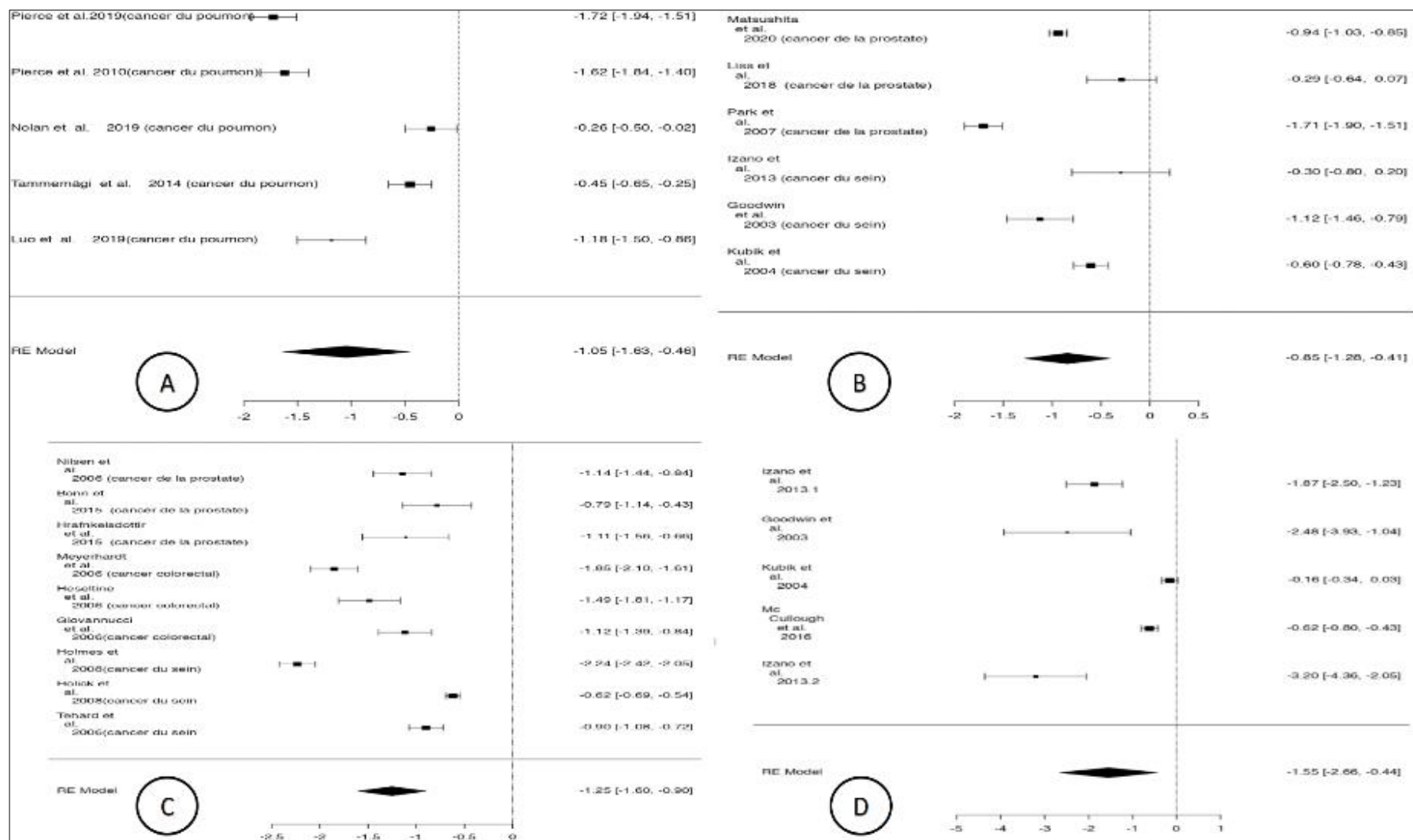


Figure 2 Association between cancer incidence and prevention measures with an  $I^2$  between 90.51 and 99%: (A Tobacco control, B Nutritional diet, C Physical activity, D Human papilloma vaccine)

**Table 1** Data extraction grid for measuring tobacco control

Author, year, reference	Title	Type of cancer	Country	Type of study	Duration of study	Endpoint	Population studied	Main results
Gredner et al. 2021 (11)	“Impact of tobacco control policies implementation on future lung cancer incidence in Europe: An international, population-based modeling study”	Lung cancer	30 European countries	Prospective study	-	The impact	Sample of 30 European countries	Improving and expanding the implementation of tobacco control policies could significantly reduce the future incidence of lung cancer
Pierce et al. 2019. (12)	“Trends in lung cancer and cigarette smoking: California compared to the rest of the United States”	Lung cancer	The United States	Prospective study	6 years	Mortality at 6 years	962,174 persons	
Pierce et al. 2010 (13)	“Forty Years of Faster Decline in Cigarette Smoking in California Explains Current Lower Lung Cancer Rates”	Lung cancer	The United States	Prospective study	42 years	Mortality	Between 35,000 and 45,000 people	California's tobacco control efforts have been associated with a reduced rate of lung cancer.
Tammemägi et al. (14) 2014	“Impact of lung cancer screening results on smoking cessation”	Lung cancer	The United States	Prospective study	7 years	Mortality at 7 years	15,489 persons	HR:0,8
Ngoan 2006 (15)	“Anti-smoking initiative and decline in incidence rates of lung cancer in Viet Nam”	Lung cancer	Vietnam	Prospective study	10 years	Incidence at 6 and 10 years	100,000 smokers	California's tobacco control programs have been associated with a reduction in lung cancer.
Luo et al. 2019 (16)	“Lung cancer mortality in Australia in the twenty-first century: How many lives can be saved with effective tobacco control?”	Lung cancer	Australia	Prospective study	-	Mortality	Population of Australia	The integration of effective smoking cessation programmes into screening programmes further reduces smoking-related morbidity and mortality.
Piñeros et al. 2016 (17)	“Descriptive epidemiology of lung cancer and current status of tobacco control measures in Central and South America”	Lung cancer	18 countries in South America	Prospective study	4 years	Mortality	100,000 people/year	49% decrease in new cases of lung cancer in 2050

Soerjomataram et al. 2010 (18)	“Purchase Subscribe Save Share Reprints Request Impact of a smoking and alcohol intervention programme on lung and breast cancer incidence in Denmark: An example of dynamic modelling with Prevent”	Lung cancer	Denmark	Prospective study	40 years	Incidence at 40 years	Danish population	49% decrease in new cases of lung cancer in 2050
Gredner et al. 2020 (19)	“Impact of Tobacco Control Policies on Smoking-Related Cancer Incidence in Germany 2020 to 2050—A Simulation Study”	Lung cancer	Germany	Prospective study	-	The impact	National data on daily prevalence of smoking	13.3% of smoking-related cancer cases could be prevented if a combination of different tobacco control policies were implemented in Germany

**Table 2** Data extraction grid for the nutritional advice measure

Author, year, reference	Title	Type of cancer	Country	Type of study	Duration of study	Endpoint	Population studied	Main results
Izano et al. 2013. (20)	“Are diet quality scores after breast cancer diagnosis associated with improved breast cancer survival?”	Breast cancer	The United States	Prospective study	18 years	Survival and relapse at 18	4,103 women aged 30 to 55 with stage I, II and III breast cancer	The consumption of fruits and vegetables, as well as whole grains, is associated with a low risk of mortality by this cancer, while a large consumption of animal fats increased this risk. RR = 0.72 95% CI: 0.53-0.99
Goodwin et al. 2003 (21)	“Diet and Breast Cancer: Evidence That Extremes in Diet Are Associated With Poor Survival”	Breast cancer	-	Prospective study	1 year	Survival at 12 months	470 women with breast cancer T1 to T3	A diet rich in foods, fruits, vegetables and a hyperprotein diet prolong survival. RR = 0.81
Kubik et al. 2004 (22)	“Dietary habits and lung cancer risk among non-smoking women	Lung cancer	Czech Republic	Prospective study	-	The impact	435 women smokers and 1,710 non-smokers	Certain elements of the diet may contribute to the variation in the risk of cancer. OR = 1.00 in non-smokers Vs OR = 7.03 in smokers A diet rich in fruits and vegetables decreases the incidence: RR = 0.59 Red meat would increase this risk: HR = 1.21



								As well as obesity: HR = 1.2
Mc Cullough et al. 2016. (23)	“Pre- and postdiagnostic diet in relation to mortality among breast cancer survivors in the CPS-II Nutrition Cohort”	Breast cancer	The United States	Prospective study	2 years	Survival at 2 years	4,452 women with breast cancer	A diet in accordance with the guidelines for the prevention of cancer, reduces mortality. RR = 0.78
Izano et al. 2013. (20)	“Are diet quality scores after breast cancer diagnosis associated with improved breast cancer survival?”	Breast cancer	The United States	Prospective study	18 years	Survival at 18	4,103 women with breast cancer	adherence to a healthy diet is associated with a reduced risk of death from other causes; RR = 0.72
Georges et al. 2014. (24)	“Better post diagnosis diet quality is associated with reduced risk of death among postmenopausal women with invasive breast cancer in the women's health initiative”	Breast cancer	The United States	Prospective study	9.6 years	Mortality at 9.6 years	2,137 women with breast cancer	Better nutrition after diagnosis has been associated with a reduced risk of death. Overall mortality HR = 0.74 [95% CI: 0.55-0.99]; p = 0.043
Thomson et al. 2014. (25)	“Nutrition and physical activity cancer prevention guidelines, cancer risk, and mortality in the women's health initiative”	Breast cancer	The United States	Prospective study	5 years	Mortality at 5 years	65,838 women aged between 50 and 79	Healthy lifestyle behaviours recommended for nutrition and physical activity may be associated with a lower risk of cancer and death in postmenopausal women. HR = 0.78 (95% CI, 0.67-0.92)
Zhou et al. 2005, (26)	“Dietary iron, zinc, and calcium and the risk of lung cancer”	Lung cancer	The United States	Prospective study	8 years	Incidence at 8 years	923 patients with lung cancer and 1,125 patients with a healthy situation	Dietary iron, zinc and calcium could play an important role in the development of lung cancer, especially in current smokers OR = 1.45 (95% CI, 1.03-2.06)
Fraser et al. 1991 (27)	“Diet and lung cancer in California Seventh-day Adventists”	Lung cancer	The United States	Prospective study	6 years	Incidence at 6 years	61 patients with lung cancer	Fruit consumption significantly reduces the risk of cancer. Fruit consumption < 3 times/week decreases this risk and the RR = 1.0; Fruit consumption 3-7 times/week, decreases the risk of RR cancer = 0.30; fruit consumption more than once a day decreases cancer incidence RR = 0.26

Matsushita et al. 2020 (28)	“Influence of Diet and Nutrition on Prostate Cancer”	Prostate cancer	The United States	Prospective study	-	Incidence and mortality	3,373 men with a BMI > 27.8	A Western diet increases incidence and mortality. RR = 1.7/HR = 1.71
Liss et al. 2018 (29)	“Higher baseline dietary fat and fatty acid intake is associated with increased risk of incident prostate cancer in the SABOR study”	Prostate cancer	The United States	Prospective study	10 years	Incidence at 10 years	1903 men joined the study	Total dietary fats and certain fatty acids are associated with an increased risk of prostate cancer. HR 1,19; 95% CI, 1.07-1.32;
Park et al. 2007 (30)	“Fat and meat intake and prostate cancer risk: The multiethnic cohort study”	Prostate cancer	The United States	Prospective study	8 years	Incidence at 8 years	82,483 men > 45 years of age	No association between fat and meat consumption and prostate cancer risk RR = 1,00
Malila et al. 1998 (31)	“A comparison of prospective and retrospective assessments of diet in a study of colorectal cancer”	Colorectal cancer	-	Retrospective study	1 year	The incidence at 1 year	A random control group	No association between dietary factors and colorectal cancer risk RR = 0.79 (CI = 95%; 0,48-1,30)
Jedrychowski et al. 2001 (32)	“Nutrient intake patterns in gastric and colorectal cancers”	Colorectal cancer	Poland	Prospective study	-	The impact	180 cases of colorectal cancer	High carbohydrate intake has been associated with an increased risk of colorectal cancer OR = 2.45
Van Blarigan et al. 2015. (33)	“Role of Physical Activity and Diet After Colorectal Cancer Diagnosis”	Colorectal cancer	The United States	Prospective study	2 years	Survival over 2 years	1,264 patients with colorectal cancer stage III	Study confirms association between Mediterranean diet and colorectal cancer-specific overall survival HR = 0.62 (95% CI, 0.53 - 0.72)
Gonzalez et al. 2011, (34)	“Dietary factors and in situ and invasive cervical cancer risk in the European prospective investigation into cancer and nutrition study”	Cervical cancer	10 European countries	Prospective study	6 years	Incidence and mortality at 5 years	299,649 women between the ages of 35 and 70	The consumption of fruits and vegetables and meals rich in fiber plays a protective role against cancer, as well as on mortality HR = 0.85

**Table 3** Grid of extraction of data concerning measure of physical activity

Author, year, reference	Title	Type of cancer	Country	Type of study	Duration of study	Endpoint	Population studied	Main results
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Holmes et al. 2005. (35)	"Physical activity and survival after breast cancer diagnosis"	Breast cancer	The United States	Prospective study	4 years	Incidence and survival at 4 years	2987 women with breast cancer	Physical activity reduces the incidence of breast cancer, but the effect on recurrence or survival after a breast cancer diagnosis is not known. OR = 0.24
Holick et al. 2008. (36)	"Physical activity and survival after diagnosis of invasive breast cancer"	Breast cancer	The United States	Prospective study	13 years	Mortality	4482 women with breast cancer	The study confirms the reduction in overall mortality from breast cancer in women who engage in physical activity after diagnosis. HR = 0,8
Tehard et al. 2006. (37)	"Effect of physical activity on women at increased risk of breast cancer: results from the E3N cohort study"	Breast cancer	France	Retrospective study	12 years	Incidence at 12 years	3,424 women with breast cancer	A reduction in breast cancer risk was particularly observed with vigorous recreational activity. RR = 0.7
Joanna Kruk 2007. (38)	"Lifetime physical activity and the risk of breast cancer: a case-control study"	Breast cancer	Poland	Prospective study	4 years	Incidence at 4 years	250 women with histologically confirmed breast cancer aged 35 to 75 years.	Physical activity is associated with a decreased risk of breast cancer. RR = 0.51
Meyerhardt et al. 2006 (39)	"Physical activity and survival after colorectal cancer diagnosis"	Colorectal cancer	-	Prospective study	-	Mortality	573 women with colorectal cancer stage I to III excluding women who died after 6 months following the evaluation of their physical activity after diagnosis.	Recreational physical activity after diagnosis of colorectal cancer (stage I to III) may reduce the risk of colorectal cancer-specific mortality and overall mortality. HR:0,6
Heseltine et al. 2006. (40)	"Impact of physical activity on cancer recurrence and survival in patients with stage III colon cancer: findings from CALGB 89803"	Colorectal cancer	-	Prospective study	-	Mortality and survival	832 patients with stage III colon cancer	Physical activity can reduce the risk of recurrence and mortality.

Giovannucci et al. 2006 (41)	“Physical activity and colorectal cancer survival: the more METS the better”	Colorectal cancer	The United States	Prospective study	5 years	Mortality	573 women with stage I, II and III colorectal cancer.	The study concluded that women with non-metastatic colorectal cancer who were physically active after diagnosis had a reduced risk of colorectal cancer-specific mortality and overall mortality. HR = 0.79
Littman et al. 2006. (42)	“Recreational physical activity and prostate cancer risk (United States)”	Prostate cancer	The United States	Prospective study	3 years	Incidence at 3 years	34,757 elderly men	Physical activity is not associated with a decreased risk of prostate cancer.
Wiklund et al. 2008. (43)	“Lifetime total physical activity and prostate cancer risk: a population-based case-control study in Sweden”	Prostate cancer	Sweden	Prospective study	-	The impact	1,449 men with prostate cancer	Study fails to confirm that physical activity uniformly protects against prostate cancer development OR = 1.04
Zeegers et al. 2005. (44)	“Physical activity and the risk of prostate cancer in the Netherlands cohort study, results after 9.3 years of follow-up”	Prostate cancer	The Netherlands	Prospective study	9.3 years	Incidence at 9 years	58,279 men including 1,386 with prostate cancer	The study could not support the hypothesis that physical activity protects against prostate cancer in men. RR = 1.01
Hrafnkelsdottir et al. 2015 (45)	“Physical Activity from Early Adulthood and Risk of Prostate Cancer: A 24-Year Follow-Up Study among Icelandic Men”	Prostate cancer	Iceland	Prospective study	20 years	Incidence at 19 years	9,115 men	Study showed physical activity is linked to decreased risk of prostate cancer HR = 0.67
Nilsen et al. 2006. (46)	“Recreational physical activity and risk of prostate cancer: A prospective population-based study in Norway (the HUNT study)”	Prostate cancer	Norway	Prospective study	2 years	Incidence is 1 and a half years	36,522 men with prostate cancer	Physical activity can reduce the risk of prostate cancer, and potentially protect against mortality. RR = 0.67
Bonn et al. 2015. (47)	“Physical activity and survival among men diagnosed with prostate cancer”	Prostate cancer	Norway	Prospective study	5 years	Mortality	4,623 men with prostate cancer	The study demonstrated that higher levels of physical activity were associated with reduced overall and prostate-specific mortality rates.

								HR = 0.63
Kim Lam et al. 2013. (48)	“Anthropometric Measures and Physical Activity and the Risk of Lung Cancer in Never-Smokers: A Prospective Cohort Study”	Lung cancer	The United States	Prospective study	2 years	Incidence at 2 years	158,415 non-smoking men and women	The study found no association between baseline or mean age BMI and decreased risk of lung cancer in non-smokers. RR = 1.21
Sinner et al. 2006. (49)	« The association of physical activity with lung cancer incidence in a cohort of older women: the Iowa Women's Health Study”	Lung cancer	The United States	Prospective study	16 years	Incidence at 15 years	36,929 women with no history of cancer.	The study showed that physical activity could reduce the risk of lung cancer in women who are current or former smokers. RR = 0.77
Steindorf et al. 2006 (50)	“Physical activity and lung cancer risk in the European Prospective Investigation into Cancer and Nutrition Cohort”	Lung cancer	10 European countries	Prospective study	8 years	Incidence at 8 years	416,227 men and women, 1,083 of whom have lung cancer.	The study could not demonstrate any association between recent occupational, leisure or domestic physical activity and lung cancer risk in men and women RR = 1.57, OR = 0.65
Thune et al. 1997 (51)	“The influence of physical activity on lung-cancer risk: A prospective study of 81,516 men and women”	Lung cancer	-	Prospective study	6 years	The impact 5 ½ years	53,242 men and 28,274 elderly women including 413 men and 51 women with lung cancer	No consistent association between physical activity and lung cancer risk was observed in women. However, recreational physical activity has a protective effect on the risk of lung cancer in men. RR = 0.71
Rundle et al. 2010 (52)	“Physical activity and lung cancer among non-smokers: a pilot molecular epidemiological study within EPIC”	Lung cancer	7 European countries	Prospective study	10 years	Incidence at 10 years	878 non-smoking men and women at the start of the study	Physical activity was not associated with lung cancer risk or biomarker levels. OR = 0.56

**Table 4** Data extraction grid for the HPV vaccination measure

Author, year, reference	Title	Type of cancer	Country	Type of study	Duration of study	Endpoint	Population studied	Main results
Inturrisi et al. 2021 (53)	“Estimating the direct effect of human papillomavirus vaccination on the lifetime risk of screen-detected cervical precancer”	Cervical cancer	Netherlands	Prospective study	-	The impact	21,287 women	The lifetime risk of cervical cancer (CIN3 +) is 4.1%
Arbyn et al. 2018 (54)	“Prophylactic vaccination against human papillomaviruses to prevent cervical cancer and its precursors”	Cervical cancer	-	Prospective study	-	The impact	73,428 women with cervical cancer.	The risk of cervical cancer: Risk with placebo: 113/10,000 Risk with HPV vaccine: 6/10,000 (95% CI) With an RR = 0.05
Tabibi et al. 2022 (55)	“Human Papillomavirus Vaccination and Trends in Cervical Cancer Incidence and Mortality in the US”	Cervical cancer	Switzerland	Prospective study	16 years	Incidence and mortality at 15 years	Women and girls aged 15-39	Risk of cervical cancer by age group: 25-29 years: Incidence = -16.16% 25-29 years: Mortality = -4.36% 30-39 years: Incidence = -8.03% 30-39 years: Mortality = -4.71%
Schneider et al. 2007 (56)	“[Impact of vaccination against oncogenic human papillomavirus on the incidence and mortality of cervical cancer in Germany]”	Cervical cancer	Germany	Prospective study	-	Mortality	399,400 girls	Vaccination was able to reduce mortality by 70% and lethality by 30.2%
Kjaer et al. 2021 (57)	“Real-World Effectiveness of Human Papillomavirus Vaccination Against Cervical Cancer”	Cervical cancer	Denmark	Prospective study	13 years	The impact	867,689 women	The effectiveness of the HPV vaccine against cervical cancer at the population level is high in girls vaccinated before the age of 20. RR = 0.85

**Table 5** Data extraction grid for the measure against alcoholism

Author, year, reference	Title	Type of cancer	Country	Type of study	Duration of study	Endpoint	Population studied	Main results
Jiang et al. 2019 {Citation}	“Can public health policies on alcohol and tobacco reduce a cancer epidemic? Australia's experience”	Lung cancer Breast cancer Colorectal cancer	Australia	Prospective study	5 years	Incidence at 5 years	Annual chronological data based on population between 1950 and 2013	Public health policies have been linked to changes in alcohol consumption among the population Lung cancer: RR = 0.17 Breast cancer: RR = 0.05 Colorectal cancer: RR = 0.18
Soerjomataram et al. 2010 (58)	“Purchase Subscribe Save Share Reprints Request Impact of a smoking and alcohol intervention programme on lung and breast cancer incidence in Denmark: An example of dynamic modelling with Prevent”	Breast cancer	Denmark	Prospective study	-	The impact	Population of Denmark	An intervention aimed at immediately reducing the population's alcohol consumption to the recommended level (less than 12 g/d) could reduce the number of breast cancers by 7%, which would avoid 445 of the 6060 new cases expected in 2050

#### 4. Discussion

This study is a systematic review whose aim is to evaluate the effectiveness of the main public health measures in the fight against cancer through observational studies.

In this study, we selected 51 articles studying 5 public health measures. Meta-analysis showed great heterogeneity with an  $I^2$  between 90.51% and 99%. This heterogeneity can be explained by the variability of the criteria of judgment, the type of cancer and the population studied.

However, despite this great heterogeneity, the results of this review showed that the public health measures studied had a positive impact on the epidemiology of cancers by reducing their incidence and extending the life expectancy of cancer patients.

- Smoking is a public health problem of the highest importance in the world. An estimated 1.3 billion people (22% of the population) currently use tobacco. It is responsible for 25% of cancer deaths worldwide (59).

This scourge is the cause of many types of cancer, including cancer of the lung, larynx, mouth, esophagus, bladder, kidneys, liver, stomach, pancreas, colon and rectum and cervix, as well as acute myeloid leukemia. Smoking has a negative impact on the prognosis of many types of cancer (60).

Given the progress made in the implementation of tobacco control policies in different countries, several studies have sought to estimate the impact of the implementation of tobacco control policies on the incidence of cancers and particularly on the incidence of lung cancer. The results of our systematic review suggest that of all the cases expected between 2006 and 2050 in the different countries studied, about 20% to 30% (the preventive fraction =  $1-OR$ ) of lung cancers could be avoided if tobacco control policies were implemented at the highest level.

Research by Gredner et al in 2021 (61) has shown that tobacco control strategies implemented in Australia, including price increases, neutral packages, more comprehensive tobacco control laws and intensified media campaigns, have successfully contributed to the decline in cancer incidence.

Our results were consistent with data published in the literature; Qingwein Luo et al in 2017 (62) showed that the implementation of a series of tobacco control interventions played a crucial role in the decline in smoking prevalence and cigarette consumption observed in many countries, and these measures have clearly led to significant reductions in the occurrence of lung cancer.

According to Pierce et al (63), thanks to the taxation of tobacco and the neutralization of cigarette packets, there has been a 20% reduction in mortality due to lung cancer, as well as an estimated 21% to 50% reduction by 2030 in total deaths related to smoking.

In a systematic review of Harm Reduct J (64), he established that smoking is the leading cause of lung cancer. Nevertheless, stopping smoking clearly reduces its mortality. Data from this case-control study show that former smokers have a 20% reduction in mortality risk compared to current smokers.

From all the articles included, it can be concluded that the declines in lung cancer incidence rates as a result of declining smoking rates demonstrate the effectiveness of policies and highlight the potential benefits of strengthening prevention efforts.

- The field of investigation of the role of nutrition in the cancer process is very broad. Nutrition plays a major role in cancer. Poor nutrition can increase the risk of developing different types of cancer, including colorectal cancer, breast cancer, stomach cancer, esophageal cancer, liver cancer and pancreatic cancer (65).

Human diet studies have shown a 30% reduction in breast cancer rates and a 41% reduction in colon cancer rates in men without known modifiable risk factors, as well as the incidence of lung and prostate cancer.

According to a systematic review by Timothy J Key (66), chemicals used to preserve processed meat, such as nitrates and nitrites, could increase the exposure of the intestine to mutagenic compounds. Thus a higher consumption of milk and calcium is associated with a moderate reduction in the risk of colorectal cancer:



Calcium could have a protective effect by forming complexes with secondary bile acids and heme in the intestinal lumen.

According to a study by McCullough et al. 2016 (67), excessive consumption of foods rich in salt and pickled vegetables, as well as insufficient consumption of fresh vegetables and fruits, are triggers of colorectal cancer. In contrast, high consumption of green and yellow vegetables, fruits and fiber is considered beneficial and protective against lung, breast and colon cancer.

According to Georges et al (68), strong adherence to the Mediterranean diet reduced the risk of breast and lung cancer by 63%, and average adherence reduced the risk by 51%.

Strong commitment to the Mediterranean model was associated with a breast cancer risk of less than 6% in the EPIC (European Prospective Investigation into Cancer and Nutrition) study (69) and in an updated meta-analysis (70), and from 15% in a cohort study in France (71) to 44% in a Spanish case-control study.

Our results are consistent with a prospective study by Ferlay, J in 2016 (72), which indicated that diets higher in fruits and vegetables are associated with a slightly lower risk of lung cancer in smokers, but not in people who have never smoked.

A meta-analysis by Karen Canfell et al (73) indicated that the risk of developing cancer could be reduced with higher levels of other micronutrients, including  $\beta$ -carotene, vitamin D, vitamin E and selenium, but the results of trials and analyses are generally inconclusive.

The number of studies evaluating cancer recurrence was small, but according to Beata Krusińska et al in 2017 (74), a Western dietary model is associated with an increased risk of cancer recurrence in colorectal cancer survivors.

According to a meta-analysis done by Lukas Schwingshackl in 2018 (70), the reduction of dietary fat after cancer diagnosis could increase survival without relapse in survivors, and that adherence to the 'alternative healthy eating index' (AHEI) diet and the Mediterranean diet after diagnosis is associated with a decrease in mortality.

Based on our systematic review and the results of the meta-analyses, we were able to provide important additional evidence of the beneficial effect of a high adherence to the diet with respect to the primary prevention of the overall risk of cancer and certain other types, as well as their mortality. These observed beneficial effects are mainly due to higher consumption of fruits, vegetables and whole grains.

- Increasingly, studies show the benefits of physical activity in primary and tertiary prevention, especially for cancer patients.

About the cancers included in the meta-analysis, many studies have shown that those who are physically active have a lower risk of cancer than those who are inactive.

In the prospective study done by Holmes et al in 2005 (75) involving 2987 women, concluded that the most physically active had a 12 to 21% lower risk of breast cancer than the least physically active women. The latter has been associated with similar reductions in breast cancer risk in pre-menopausal and post-menopausal women.

Our results are consistent with a 2013 meta-analysis (76) of 31 prospective studies that showed that the average reduction in breast cancer risk associated with physical activity was 12%, and that the protective effect was greater in postmenopausal women.

In a meta-analysis done by Behrens G in 2018 (77), Jochem C in 2016 (77) containing 126 studies, people who practiced the highest level of physical activity had a 19% lower risk of colon cancer than those who were the least physically active.

Long-term similar studies show that the participants who practice a physical activity softened in vigorous during more than three hours a week have a risk of cancer reduced from 30 to 40 %.

This meta-analysis also showed that physical exercise has a positive effect on the limitation of the repetition at the patients attained by cancer. More particularly, the breast cancer, colorectal and of the prostate.

Moderate exercise seems to have a protective effect on the immune system of the general population.

Dhabhar (78) suggests that the potentiation of immune agents resulting from exercise is due to the bi-directional effect of hormones of stress on immunity, where subtle elevation is advantageous, while significant and supported elevation (as it is seen with an effort prolonged and/or intensive) is detrimental to the guest. The function of the immune system during or after cancer therapy is important for cancer outcomes such as complications and/or risk of recurrence. Strengthening the immune system can help breast cancer patients with an increased risk of recurrence. Knowledge of fundamental immunology suggests an appropriate appreciation of the role of physical exercise in reducing the risk of cancer recurrence.

In addition, it is reported that exercise can induce cancer cell apoptosis and inhibit cancer growth in animal and in vitro experiments, although the mechanism of these exercise effects is unclear.

Observational studies by Wendy Demark-Wahnefried (79) in 2006 and Holick et al 2018 (80) of breast, colon, prostate and lung cancer survivors show strong associations between post-diagnosis exercise and decreased cancer-specific mortality.

The amount and intensity of exercise required to measure a survival benefit appears to vary depending on the type of primary tumor. A decrease in breast cancer mortality is observed with the equivalent of 3 hours of walking per week, and a decrease in colon cancer mortality with 6 hours of walking per week.

Exercise can also reduce the side effects of cancer treatments and facilitate recovery and rehabilitation after chemotherapy, radiation and surgery.

This systematic review and meta-analysis demonstrated that exercise has a positive effect on mortality and recurrence rates in cancer patients.

- Cervical cancer is by far the most common disease related to HPV. Approximately 99.7% of cervical cancer cases are due to persistent high-risk genital infection with human papillomavirus (HPV). The introduction of HPV vaccines has reduced the prevalence and diseases associated with HPV, CIN and cervical cancer. The implementation of an HPV vaccination program has led to a dramatic decrease in the rate of cervical cancer.

The results we obtained are in agreement with a meta-analysis done by Renjie Wang et al in 2020 (81), the 4vHPV vaccine showed that up to about 90% of HPV-6/11/16/18 infections were reduced compared to unvaccinated populations. The incidence of histologically proven low-grade cytological abnormalities of the cervix (about 45%) and high-grade abnormalities of the cervix (about 85%) continued to decrease.

According to a study carried out by S.Hantz et al in 2006 (82), the first clinical trials revealed the good tolerance and excellent immunogenicity of the vaccines. After more than three years, the clinical trial on women aged 15 to 25 years showed that vaccines are able to protect against nearly 90% of infections and all intra-epithelial neoplasms of the cervix, while protecting against HPV infections in unvaccinated people, a phenomenon known as herd immunity.

In terms of cervical cancer mortality, the HPV vaccine has been able to reduce the number of deaths related to this disease.

The vaccine prevented precancerous lesions in randomized clinical trials and was associated with a decrease in cervical cancer mortality in a German observational study by Schneider et al in 2007.

Based on the findings of two separate studies, one conducted in Denmark by Kjaer et al in 2021 (83) and the other conducted in Australia by Berenson AB et al 2007 (84), demonstrated a significant reduction in deaths associated with cervical cancer following the introduction of the vaccine.

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## 5. Conclusion

Through our study, we were able to highlight the influence of public health measures on the incidence and lethality of cancers.

Indeed, the analysis of the data collected made it possible to emphasize the importance of integrating these measures into the overall management of adult patients with cancers. The most relevant measures identified in this review are

the promotion of a balanced diet, awareness of the importance of regular physical activity, efforts to discourage tobacco and alcohol consumption, and vaccination against human papillomavirus.

Our initial study provided preliminary results that require further exploration, particularly through prospective studies, to validate the various information obtained.

In addition, it would be beneficial to extrapolate these results to the population level in order to better understand the extent of the impact of public health measures on cancer prevention and management.

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## Compliance with ethical standards

### *Acknowledgments*

The authors would like to thank anonymous reviewers for constructive comments on the manuscript.

### *Disclosure of conflict of interest*

The authors have no conflicts of interest.

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