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Integration of Smoking Cessation with Lung Cancer Screening: A Survey of Best Practices in the EU

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Abstract

Combining low-dose CT lung cancer screening (LCS) with smoking cessation has emerged as a next-generation intervention to reduce the human and societal burdens of lung cancer. This study reviews the evidence supporting both strategies—individually and in combination—acknowledging that not all real-world smoking cessation interventions can be seamlessly integrated with LCS. While linking these strategies might enhance their respective primary endpoints, it is essential to ensure their integration does not inadvertently interfere with their individual outcomes. We present results of a survey on current best practices in the EU27 and propose key areas for further research. These insights provide a foundation for future EU Commission-funded projects.

Keywords: Smoking Cessation; Lung Cancer; Screening; Low-Dose CT Scan; Nicotine Substitution Therapy; Quit Rate; Cost-Effectiveness; Cytisinicline; Behavioral Therapy

Abbreviations: CEA: cost-effectiveness analysis; EU27: the 27 countries of the European Union; F2F: face-to-face; ICER: Incremental Cost-Effectiveness Ratio; LCS: lung cancer screening; LD-CT: low-dose computerized tomography scan; N-AC: nicotinic-acetylcholine; NRT: nicotine replacement therapy; QALY: Quality Adjusted Life Years; RCT: randomized clinical trial; SSS: stop smoking services; USPSTF: US Preventive and Screening Task Force; 95% CI: 95% confidence interval

Introduction

Lung cancer is an important health burden for the 27 countries of the European Union (EU27): with more than half a million new cases annually and an average 5-year survival rate of 12%, it ranks among the deadliest cancers—with a mortality rate higher than that of colorectal and breast cancer combined [1]. Its societal (direct and indirect) cost for the entire EU population in 2019 amounts to approximately € 230×10^9, driven by expenses for immunotherapy and targeted agents and accounts for nearly a quarter of productivity losses due to premature mortality, which is higher than for any other cancer type [2]. The main reason for these dismal figures is that lung cancer is diagnosed at an advanced stage, necessitating high costs for palliative treatment in patients with frequent comorbid diseases. Curbing this epidemic necessitates an innovative and preventive approach and combining smoking cessation with early diagnosis of lung cancer is the logical way forward.

The most important risk factor for lung cancer is, indeed, chronic tobacco smoking [3]. Nineteen percent of Europeans aged 55 or more smoke daily [4]. This high prevalence translates into a tobacco-use-linked cancer mortality rate of the upper and lower airways ranging from 38 per 100,000 persons (in 45–64-year-olds) to 112 per 100,000 persons (in individuals aged 65 years or more. Thus, both primary smoking prevention and secondary smoking cessation are the most obvious actions to curb the lung cancer epidemic.

Lung cancer screening (LCS) by low-dose CT scan (LD-CT) has repeatedly been shown in systematic reviews to significantly reduce lung cancer mortality by at least 20% and overall mortality by approximately 5% [5]. Compared to screening with a chest X-ray or no screening, LD-CT has proven to be feasible, safe, and effective. In a systematic review of cost- effectiveness analyses (CEAs) from 23 countries, LCS was associated with ICERs varying from € 1,772 to € 63,269 per QALY [6]. Annual LCS is now recommended and reimbursed as a preventive intervention in high-risk populations of current or former smokers in several countries in North America, the United Kingdom, Australia, and East Asia. The implementation of a population-based LCS program in the EU27 is slowly gaining momentum, with Croatia taking the lead in 2019 and Poland and the Czech Republic transitioning from pilot studies to population-based implementation [7]. Approval for the latter have also recently been granted in France and Norway. In 2022, the Council of the EU27—although not formally authorized to act on healthcare—updated its recommendation as part of "Europe's Beating Cancer Plan," by stating that countries should explore the feasibility and effectiveness of LCS by LD-CT in high-risk current and ex-smoking individuals [8]. This recommendation resulted in EuCanScreen, a European Joint Action on Cancer Screening project that investigates the implementation of novel screening programs for -among others- lung cancer.

Approximately 60% of patients eligible for LCS in the US continue to smoke [9], making it essential to support tobacco cessation in this population. In addition to the benefits of early diagnosis, any preventive screening program for lung cancer provides an ideal opportunity to discuss tobacco dependence. This is particularly important given that continuing to smoke after a diagnosis of early-stage lung cancer nearly doubles the mortality risk by increasing the likelihood of cancer recurrence, development of a second primary tumor, or all-cause mortality [10]. According to the health behavior model of "the teachable moment hypothesis", the perception of a health threat increases the likelihood of making behavioral changes and enhances the effectiveness of behavioral interventions [11]. This theory is based on three parameters for an increased likelihood of behavioral change: (i) an increased perception of personal risk; (ii) the creation of an emotional response; and (iii) a change in the person's self-perception. The teachable moment model thus provides a conceptual framework for including a smoking cessation trajectory within the screening program.

Formal smoking cessation programs increase the likelihood of quitting and decrease overall as well as lung cancer-specific mortality [12]. Literature indicates that, while various smoking cessation interventions have been effective in the general population, their efficacy in a LCS- eligible populations is less clear and underscore the need to consider effectiveness, implementa-

tion, and impact, particularly in specific populations [13]. The available evidence evaluated various interventions, including pharmaco- and behavioral therapy. In the RCT's addressing its efficiency, LCS had no extra effect on smoking status compared with the control group, but overall the screening program probably promoted smoking cessation and in some quit rates were higher and relapse rate lower among subjects with initial Ct-scan findings that necessitated a repeat scan [14]. Of note, these RCT's were neither designed nor powered to address any smoking cessation issue.

Pharmacotherapy includes the provision of diverse formulations of nicotine replacement therapy (NRT) or of partial agonists of the α4β2 nicotinic acetylcholine (N-AC) receptor, which is involved in the transmission of the addiction pathway at the level of the basal nuclei in the brain. The reader is referred to a comprehensive review on this topic [15]. A recent systematic review with meta-analysis concluded that NRT has high-quality evidence for increasing smoking abstinence by 60–70% [16]. Furthermore, all formulations of NRT are equally effective in various clinical settings, meaning that their relative effect is independent of and additive to other non-pharmacological interventions. Lastly, they have mild side effects, and there are few, if any, absolute contraindications to their use. The N-AC receptor agonist varenicline has been withdrawn from the market for safety reasons. An analog drug, cytisinicline, is an effective and low-cost aid for tobacco cessation and appears to be more effective than placebo, no intervention, usual care, and even nicotine replacement therapy [17]. Cytisinicline has been approved as a smoking cessation medicine and is available as a generic compound with fewer side effects than varenicline.

Behavioral interventions can take several forms, from brief advice to intensive face-to-face counseling over the telephone or by digital applications. In-person counseling interventions range from brief, one-time sessions to more intensive, multi-session programs. These sessions may include motivational interviewing and tailored support based on individual needs. The evidence suggests that in-person counseling is one of the most effective interventions, with significant increases in smoking cessation rates. Telephone counseling involves providing support and counseling over the phone. While telephone counseling has shown promise, the articles indicate its effectiveness may not be statistically significant compared to other intervention types. However, it remains a valuable option for individuals who may not have access to in-person services. Electronic/Web-based interventions include online cessation programs, mobile applications, and text messaging support. The articles report that electronic interventions can be effective, mainly when they are interactive and provide personalized feedback. However, their overall efficacy may be lower than in-person counseling and pharmacotherapy.

Many studies have evaluated interventions combining two or more types of cessation support, such as pharmacotherapy and in-person counseling. The articles suggest that these multimodal approaches are more effective than single-modality interventions as they address various aspects of smoking cessation and provide comprehensive support. The effectiveness of the interventions was assessed at both 6-month and 12-month follow-ups. While overall efficacy decreased over time, pharmacotherapy and in-person counseling maintained statistically significant effects at the 12-month mark, indicating that these interventions can lead to sustained abstinence and should be considered standard-of-care.

A recent systematic review with meta-analysis on behavioral interventions for smoking cessation showed the highest benefit for face-to-face or group counseling (with or without a financial incentive), followed by a moderate benefit for text messaging, and low or no proven benefit for other non-pharmacological interventions [18]. The quality varies among studies, with some showing potential publication bias, particularly for in-person counseling and pharmacotherapy. However, the overall findings support the integration of smoking cessation interventions into LCS programs to improve quit rates, preferably by combining any form of counseling to pharmacotherapy. Evidence furthermore suggests that intensive interventions yield higher quit rates as they allow for continuous engagement and reinforcement of cessation efforts.

The timing of smoking cessation support is critical in enhancing the effectiveness of interventions. Interventions delivered immediately during the LCS visit are more effective than those provided later. Immediate interventions leverage the heightened motivation that patients may experience upon receiving screening results, making them more receptive to cessation support.

Follow-up support is emphasized with recommendations for ongoing contact after the initial intervention. This follow-up can help maintain motivation and address the challenges that arise during quitting. The articles suggest that structured follow-up, such as phone calls or additional counseling sessions, can significantly improve long-term cessation rates. Tailoring timing to individual needs: The articles suggest that interventions should be tailored to individual patient needs and readiness to quit. For example, some patients may require more immediate support, whereas others may benefit from a gradual approach that builds motivation over time.

The available evidence emphasizes the need to understand the demographic and clinical characteristics of populations undergoing LCS. Participants are typically older adults with a long history of heavy smoking, which can influence their readiness to quit and the types of interventions that may be most effective. Various barriers are identified which specific populations may face in accessing smoking cessation support. These barriers include a lack of awareness about available resources, stigma associated with smoking, and logistical challenges, such as transportation or financial constraints. Understanding these barriers is essential for designing effective outreach and support strategies. Individuals' readiness to quit smoking can vary significantly within the target population. Some may be highly motivated due to their LCS results, while others may be ambivalent or resistant to cessation efforts. Interventions should be adaptable to address varying levels of motivation and readiness among participants. Integrating smoking cessation interventions with other health services the target population may be accessing, such as primary care or behavioral health services. This holistic approach can enhance engagement and support individuals trying to quit smoking.

Longitudinal studies are needed to better understand how population characteristics influence the long-term effectiveness of smoking cessation interventions. Tracking outcomes over time can provide insights into which strategies work best for different demographic groups and help refine approaches to meet their needs.

The importance of ensuring that smoking cessation strategies are effective in the short term and sustainable over time. This involves embedding these interventions within the routine practices of healthcare settings, ensuring that clinic personnel are trained and confident in delivering these services consistently. To achieve sustainability, several critical features are identified, such as strong backing from healthcare organizations which is essential for maintaining smoking cessation programs, including providing resources, training, and ongoing staff support. Interventions should be adaptable to fit the specific needs and contexts of different clinics. This flexibility can enhance the likelihood of successful implementation and sustainability. Smoking cessation support should be integrated into existing LCS services, making it a standard part of patient care rather than an add-on service.

Smoking cessation is one of the most cost-effective interventions in medicine, with an Incremental Cost-Effectiveness Ratio (ICER) of 1,200–4,000 €/QALY. However, it should be remembered that it may take more than 20 years for this intervention's effects to be reflected in mortality figures [19]. Smoking cessation improves outcomes as well as the cost- effectiveness of LCS, the latter by lowering its ICER through improvements in the costs of comorbid conditions in smokers [20]. Using a validated natural history model, Meza et al. simulated that joint screening and cessation interventions would avert a considerable number of lung cancer deaths and yield significant life-years gained [21]. Adding a one-time cessation intervention of modest effectiveness (15%) results in comparable life-years gained as increasing screening uptake from 30% to 100%, because while cessation decreases mortality from many causes, screening primarily reduces lung cancer mortality. A simulation study found that LCS combined with a smoking cessation intervention reduces lung cancer mortality and increases life-years more than either intervention alone [22]. Systematic reviews have shown that 7–23% of individuals participating in LCS programs achieve smoking cessation [23,24]. In an observational, population-based cross-sectional study using data from the Behavioral Risk Factor Surveillance System of 12,382 US adults, Heiden et al. found that receipt of LCS was associated with lower smoking rates and more frequent cessation attempts [25]. They concluded that implementing LCS programs may significantly increase smoking

cessation in this population. Similar findings were reported in Australia [26].

The screening setting, therefore, represents an important opportunity to offer quit support. The US Preventive Services Task Force (USPSTF) guidelines recommend tobacco cessation counseling for smoking participants referred for LCS [27]. Yet, uncertainty remains regarding the optimal format, setting, and intensity of treatment. As more EU27 countries embark on LCS programs, we investigated whether smoking cessation is coupled with these programs and, if so, how. This manuscript reports the findings of a survey we conducted on this topic among European investigators.

Methods

We (JvM & JT) developed a survey using Google Forms™ consisting of 18 closed and semi- open questions addressing several aspects of integration smoking cessation with LCS (see Supplementary Appendix). The survey explored whether structured cessation programs are implemented—with options for brief advice, referrals, or comprehensive interventions including behavioral therapy, nicotine replacement therapies, and other medications. It also examined the enrollment model (opt-in vs. opt-out), the timing of inclusion relative to screening, and whether recent quitters are included. Success metrics for quitting, methods of abstinence confirmation, and reporting mechanisms were evaluated, alongside potential financial incentives for participants and reimbursement details.

The questions of the survey were cross-validated for completeness and clarity by a group of Finnish investigators led by TS and after amending were emailed in October 2024 to investigators in 20 European countries known to be involved in ongoing or planned implementation studies. Names and addresses were retrieved from the EUCanScreen project and from the database of the Lung Cancer Policy Network [28]. A reminder was sent one month later, and the survey was closed on December 20, 2024. Data were analyzed by JvM and JT and subsequently discussed with all coauthors, who approved the manuscript. The results are presented as a descriptive narrative.

Results

The 16 programs participating in the survey came from 13 countries (Supplementary Appendix 2). Thirteen (76%) linked a structured smoking cessation intervention to their LCS project— "structured" meaning that all current smokers in the screening project can or must enroll in a protocolized, evidence-based comprehensive smoking cessation intervention. The screening projects were either national or EU-funded in the different countries. Four programs did not implement such structured interventions; among these, most offered referrals to healthcare professionals or provided brief advice.

Face-to-face behavioral therapy conducted by healthcare professionals was the most common component (reported by 11 programs) (see Figure 1). Other elements included over-the-counter nicotine replacement therapies, non-face-to-face counseling (e.g., via apps, videos, or SMS), and non-NRT options (e.g., bupropion or varenicline). One program each used a randomized approach comparing a minimal intervention with a more intensive intervention (e.g., a smoking cessation app versus face-to--face consultations with a smoking cessation counselor). Free medication was uncommon; 12 programs provided no free drugs, while one offered nicotine substitution and another provided approved non-NRT therapy (see Figure 2).

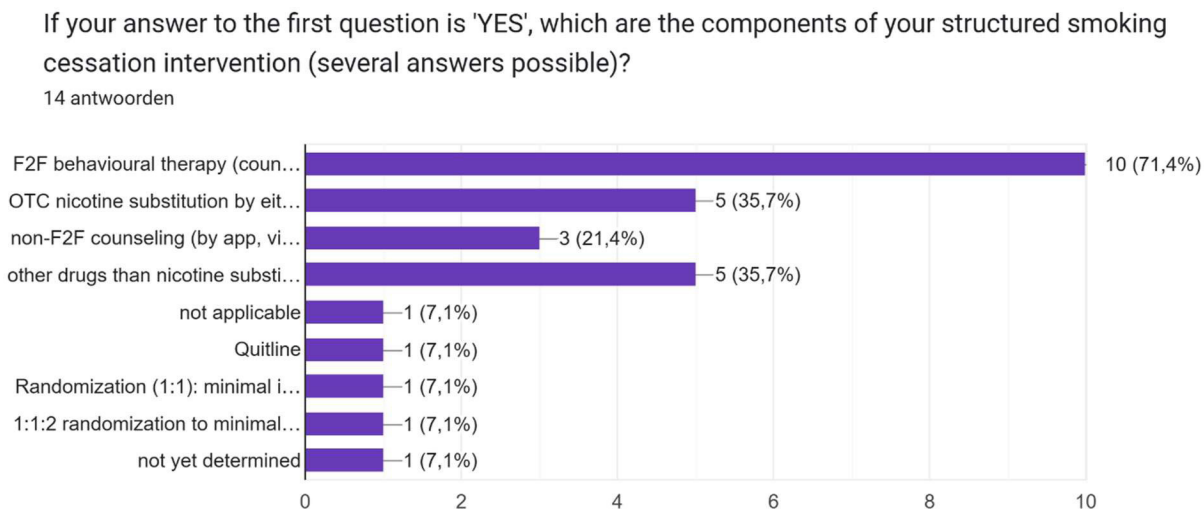

Figure 1: Responses to Question 3 regarding intervention methods

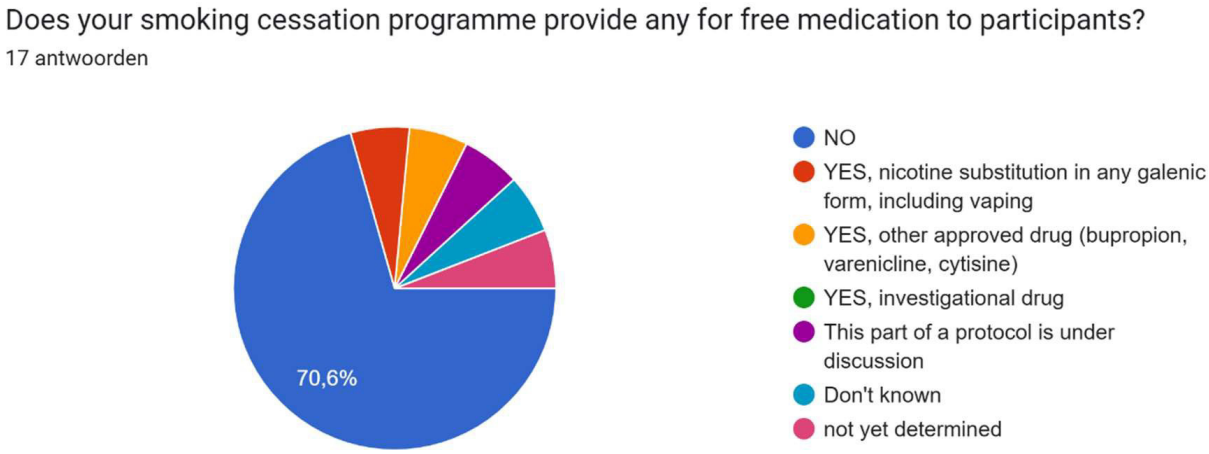

Figure 2: Responses to Question 12 regarding the provision of free medication.

In an opt-in model, smoking participants can freely choose to join the structured smoking cessation intervention, whereas in an opt-out model, all smoking participants are automatically enrolled unless they specifically decline. Nine programs employed an opt-out model, three used an opt-in model, and three indicated non-applicability. Having quit smoking or adherence to a smoking cessation program was not a prerequisite for LD-CT scans in 14 programs, although three required it. Five programs included participants who had quit smoking within the past six months for relapse prevention, whereas 10 did not. Approaches for participants unwilling to quit included motivational interviews (6 responses) and advising NRT (2 responses). Most programs (13) initiated smoking cessation during the LCS program, while four started before screening.

Time points for measuring quit success varied, with the majority assessing success after one year (5 responses). Others reported intervals at 3, 6, 12, and 24 months (see Figure 3A). Quit success was predominantly self-reported (11 responses), although some programs validated results biochemically or via carbon monoxide measurement (see Figure 3B). In most cases (12 responses), a member or investigator of the LCS program measured quit success (see Figure 3C). One response indicated measurement by another non-physician involved in smoking cessation, and two participants marked this as not applicable. Reporting methods for quit success included both point prevalence (6 responses) and continuous reporting over a given period (1 response) (see Figure 3D). Eight programs used both approaches. Definitions of the denominator used to calculate quit rates varied: some programs defined it as the total number of smokers at baseline, while others included only those who actively participated in the cessation program. Multiple interpretations were reported. Target quit rates varied: 6 programs aimed for 10–20%, 4 for 21–30%, and 3 for 31–40% (see Figure 4).

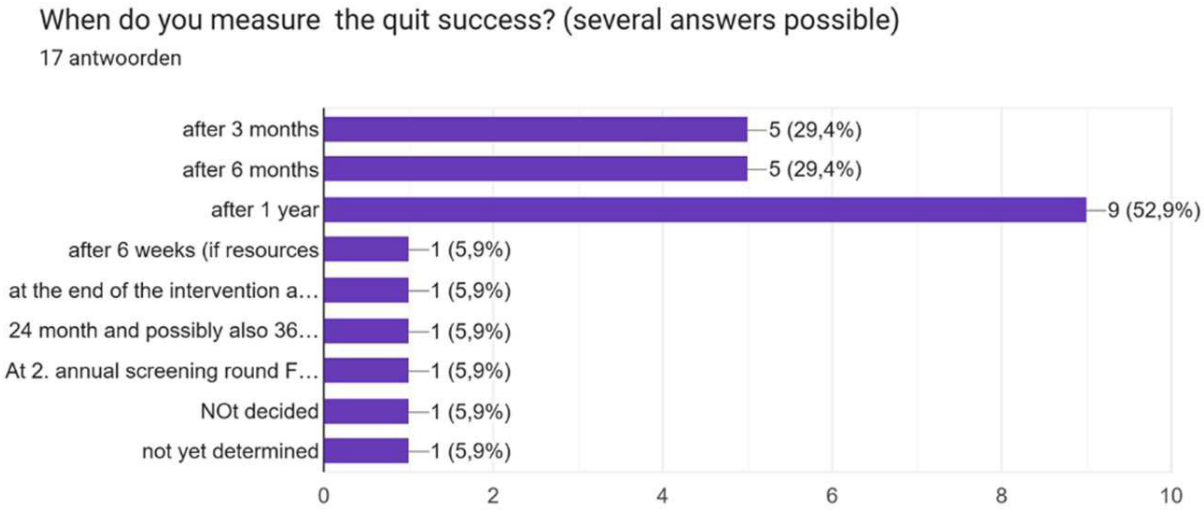

Figure 3A: Responses to Question 7 regarding time points for measuring quit success.

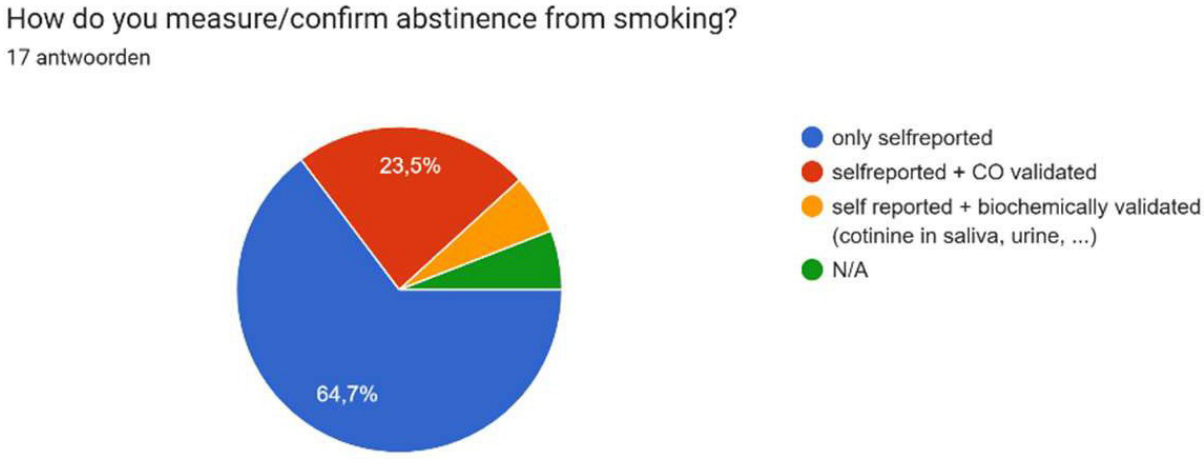

Figure 3B: Responses to Question 8 regarding methods for confirming abstinence.

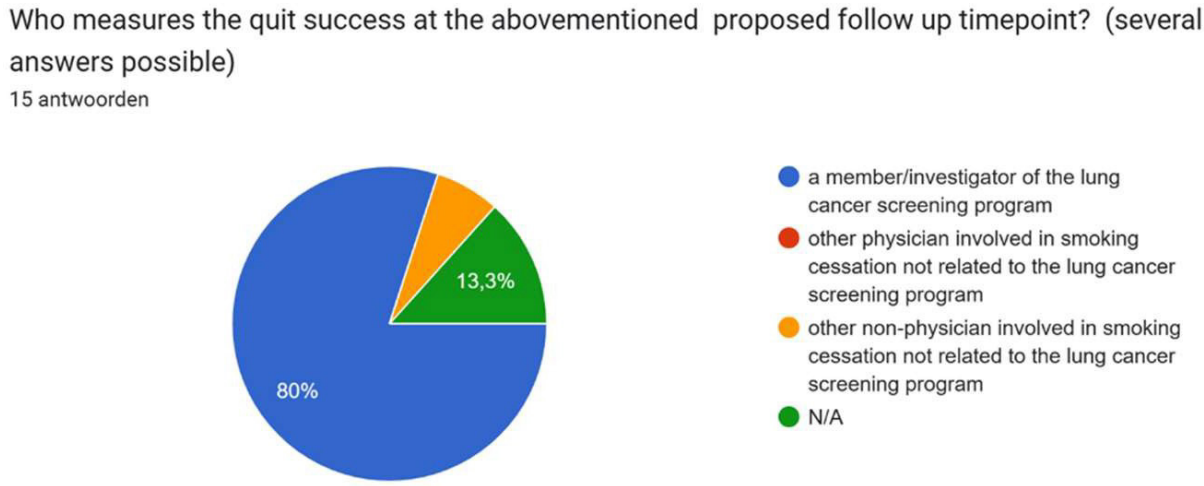

Figure 3C: Responses to Question 9 regarding the personnel responsible for measuring quit success.

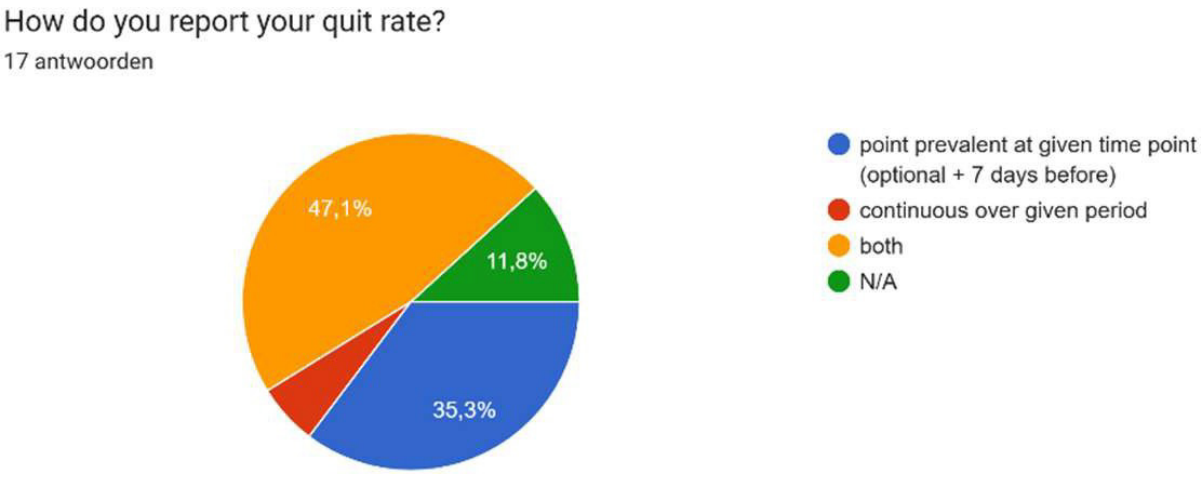

Figure 3D: Responses to Question 10 regarding reporting methods for quit rates.

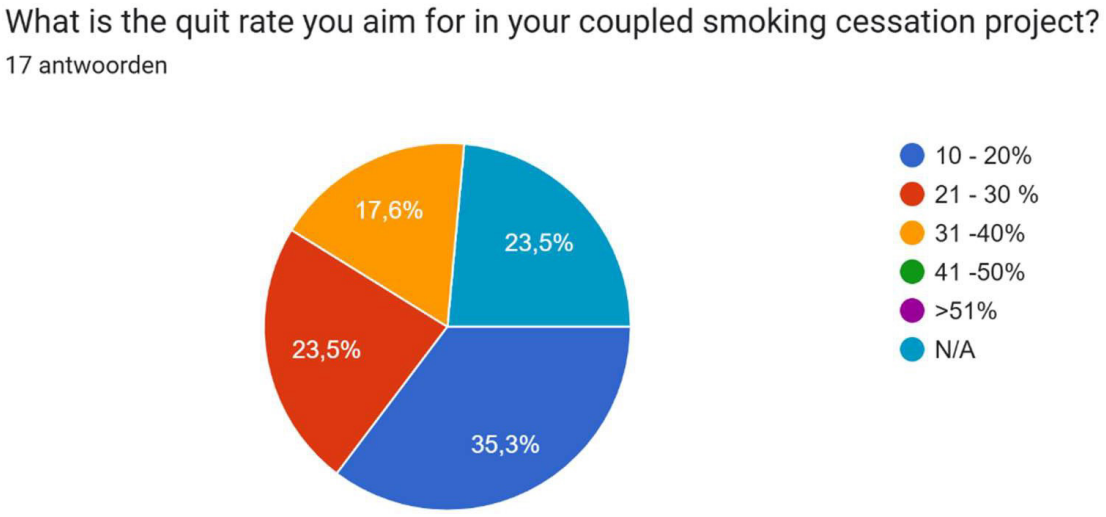

Figure 4: Responses to Question 15 regarding target quit rates.

Cost, incentives, and reimbursement: Most programs reported no out-of-pocket costs for smoking cessation programs (12 responses), while others (5 responses) indicated costs ranging from € 50 to over € 200 (see Figure 5). No program provided any financial incentives for quitting. Costs were primarily covered by social security (5 responses) or sponsors (4 responses), with three programs being reimbursed by health authorities.

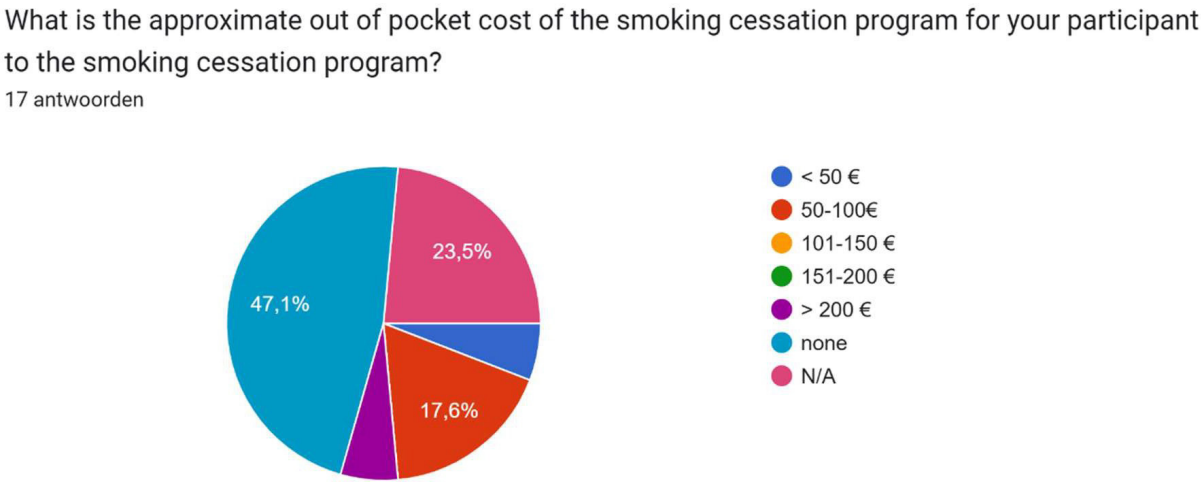

Figure 5: Responses to Question 18 regarding out-of-pocket costs

Discussion

Although there is an international consensus that smoking cessation interventions should be integrated into LCS, opinions differ on the best approach and the specific format (intensity, modalities, timing) of the intervention. Stop smoking services (SSS) can be delivered by various means, ranging from minimal intervention to intensive, structured individual or group counseling paired with pharmacotherapy. This report is the first survey on the integration of smoking cessation and LCS by LD-CT in EU-27. Its results are consistent with the reported evidence and follow the previously summarized rules and recommendations for real-world smoking cessation interventions.

Even though a subset of LCS participants may exhibit low motivation to quit smoking, existing evidence suggests that, overall, this population is motivated to cease smoking. Given that LCS provides an opportunity to intervene in a high-risk population that might otherwise not seek or receive smoking cessation services, any potentially reduced motivation should not be viewed as a reason to forgo such services. A proactive opt-out smoking cessation referral strategy was considered beneficial in an observational LCS cohort [29]. Most surveyed programs employ an opt-out model, assuming participants are motivated to quit unless they decline; however, the method of assessing motivation remains unclear.

A recent meta-analysis of randomized tobacco cessation trials in the LCS setting showed that any intervention is more effective than usual care, with more intensive interventions (3 or more sessions) being the most effective [30]. In a systematic review of 85 studies involving 94,000 potential LD-CT screening participants, the odds ratio for a successful quit at 12 months was 1.28 (95% CI, 1.09–1.51) with in-person counseling and 1.46 (95% CI, 1.17–1.84) with pharmacotherapy [31]. A population-based simulation study showed that the benefit was greatest when combining LD-CT with pharmacotherapy for nicotine dependency. Most surveyed programs combine both approaches.

Cytisinicline is the only smoking cessation compound that has been prospectively tested against usual care in the LCS setting. Pastorino et al. demonstrated a clear benefit for cytisinicline in a randomized trial among smoking participants in an LCS cohort [32]. This makes it a strong candidate for further routine implementation given its low toxicity and cost [33].

Less is known about the optimal non-pharmacological approach and its integration with pharmacotherapy. In 2016, the National Cancer Institute funded eight trials focusing on SSS in LCS-eligible tobacco users as part of the Smoking Cessation at Lung Examination (SCALE) collaboration [34]. They recruited 5,752 participants at 76 healthcare clinics across the US and used diverse approaches, including comparisons of 3 versus 6 sessions, the addition of gain-framed messages to standard care, adaptive treatment approaches, or combined interventions with the healthcare clinic and LCS care team (see Table 1). Published primary outcomes for the five completed SCALE studies were not statistically significant for group differences at long-term follow-up, and the results of three other SCALE trials are still pending. Two other randomized trials allocated participants in an LCS program to either low-intensity or high-intensity counseling with optional pharmacotherapy, with contradictory results. Although these trials do not conclusively settle the debate on whether more intensive smoking cessation interventions prevail in the LCS setting, the issue appears to be strongly linked to the combination of counseling and pharmacotherapy, a factor not adequately addressed in most RCTs.

Table 1: Randomized Trials of Smoking Cessation Interventions Embedded in an LCS Program

NCT - Trial Acronym	N Participants	Control Arm - Counseling	Control Arm - Pharmacotherapy	Experimental Arm - Counseling	Experimental Arm - Pharmacotherapy	Primary Endpoint	Result
[Reference] *		Counseling	Pharmacotherapy	Counseling	Pharmacotherapy		Odds Ratio (OR)
NCT03059940 - LUNA*	630	5 individualized telephone sessions by trained tobacco specialists + written material + webcoach	QL1: 12 weeks of single NRT or QL2: single/dual NRT or other drugs prescribed by trained LCS radiologist	IC: Referral to TTS for 8 sessions of behavioral therapy	10-12 weeks of either NRT and/or other drugs prescribed by MD of TTS	7-day point prevalent QR @ 6 months	OR: IC vs QL1: 1.86 (95% CI: 1.19-2.89); IC vs QL2: 1.25 (95% CI: 0.82-1.90)
GLCCC Screening Project*	818	3 counseling sessions by telephone	3 weeks of NRT	8 counseling sessions by telephone	8 weeks of NRT	CO-validated QR @ 12 months	OR: 1.4, 95% CI 0.82 - 2.42
QaSIS*	1100 in 26 radiology sites	Usual care without structured intervention in 13 facilities		5 intervention strategies byradiology staff in 13 facilities; Dealers choice pharmacotherapy		Self-reported QR @ 6 months	0.97 (95% CI 0.65-1.43)
PLUTO*	636	TLC	None	TLC	Combination NRT	Self-reported QR @ 6 months	Adjusted OR 1.13 (95% CI 0.67-1.89)
NCT03612804 - PROACT*	790	Usual care by primary care provider		Centralized call from quit line	Guideline-based medication mailed with screening result by primary care provider	NS	OR 1.05 (95% CI 0.67-1.64)
MOST-CASTL*	776	Cessation advice + referral to quit line	None	Cessation advice + referral to quit line +/- motivational counseling and/or message framing	NRT patches and/or lozenges	Biochemically validated QR @ 6 months	Pending
ASSIST*	640	4 'live' telehealth counseling sessions +/- referral to community resources	2 weeks NRT	'Live' telehealth counseling sessions +/- referral to community resources	8 weeks NRT	Self-reported QR @ 6 months	Pending
NCT03069924*	368	Unframed materials	None	Gain-framed video + gain-framed print materials	2 weeks NRT patches + lozenges	NS	Pending

QuLiT 1 & 2	430	Brief counseling (3A's) + referral to HCP of choice	Optional by HCP	Sessions by dedicated nurses	Dealers choice	CO-validated QR @ 12 months	Adjusted OR=2.97: (1.38 to 6.90)
NCT02658032	188	Standard of care	8 weeks NRT patch	5 in-person counseling sessions + gain-framed messaging	8 weeks NRT patch	QR @ 6 months	P = 0.87

Abbreviations: NCT: https://clinicaltrials.gov identifier; NRT: nicotine replacement therapy; CO: carbon monoxide; TLC: tobacco longitudinal care; QR: quit rate; NS: not specified; 3A's: Ask-Advice-Assist; MDACC: MD Anderson Cancer Center; QL: quit line; IC: integrated Care; TTS: tobacco treatment service; 95% CI:95% confidence interval;

*: these trials are part of the SCALE program [39]

Of special interest is the use of smartphone applications. Livanainen et al. recently reported the results of the first RCT supporting the efficacy of a smartphone application as a novel aid for tailored smoking cessation interventions specifically in LCS in Finland [35]. Given the widespread use of mobile devices, such an application could be more accessible and engaging than written material, even among the elderly. The proven effectiveness of smartphone-based interventions, mirroring results from automated digital interventions, suggests a cost-effective approach that could conserve both human and service resources. Even better results might be expected by adding pharmacological support to the application. A systematic review of a small number of trials combining pharmacotherapy with smartphone interventions demonstrated additional benefits in smoking cessation rates, indicating a need for further research in the LCS context [36].

The ideal quit rate for smoking cessation interventions within an LCS context would be at least 20–30% at 6–12 months post-intervention, with higher rates being desirable. However, quit rates can vary widely depending on factors such as the intensity of the intervention and the method of measuring abstinence. Optimal time points for assessing quit rates might include a short--term marker at 4 weeks to 3 months to capture initial abstinence (with the risk of relapse), a 6-month milestone (where those who quit are more likely to remain abstinent), and the gold standard at 12 months, when relapse rates tend to decline. Most surveyed programs require quit confirmation after one year (typically measured by self-reporting), yet there is significant variation in how a "successful quit" is defined. A standardized definition is needed for inter- program comparisons. Although the gold standard, validation of quitting is rarely done in SSS, unless as part of a clinical study. This is done by either a CO-meter or by cotinine measurement of saliva, requiring a personal appointment of the participant with the SSS provider, whilst self-reporting can be done by telephone or virtual appointment. Clearly, there is room for improvement by further research. In addition to abstinence, other endpoints may include reductions in the number of cigarettes smoked, improvements in lung function, or changes in smoking-related biomarkers (e.g., cotinine levels or exhaled carbon monoxide).

Timing is crucial when offering smoking cessation support within an LCS program. There are several key opportunities for intervention, each with its proponents and critics. Providing cessation support before LCS may help prepare individuals mentally and physically for the process and encourage greater engagement in the screening program, particularly if quitting smoking is viewed as part of a broader commitment to health. However, it may also negatively affect motivation to participate in LCS if screening is perceived as the "incentive to quit smoking". LCS offers a unique "teachable moment" since participants are already contemplating their lung health and the risks of lung cancer. Offering cessation advice during this time may increase the likelihood that participants will accept help to quit, although some argue it might serve as a "license to smoke" if a negative LDCT result provides false reassurance.

Data from the UK are reassuring that there was high uptake for co-located opt-out SSS and LCS across a wide range of participant demographics [37]. For those receiving a positive scan (i.e., an abnormal result), the pressure and anxiety of a potential diagnosis may serve as a powerful motivator for cessation. The prevailing opinion today is that evidence-based smoking cessation interventions should be provided to all smokers regardless of scan results, and motivation to quit should not be a prerequisite for LCS—a finding reflected in our survey results.

The cost of integrating smoking cessation into LCS programs can be substantial; however, these costs should be considered in light of the long-term economic and health benefits. The cost of pharmacotherapies varies widely across Europe, and reimbursement practices differ among EU27 countries. A comprehensive review of pharmacotherapy options and their cost- effectiveness in different regions is essential to ensure that the most appropriate and affordable treatments are offered. Similarly, the cost of behavioral interventions depends on their format—with intensive, multi-session therapies or telephone-based counseling requiring more resources. Digital and smartphone interventions may offer a cost-effective solution for wider reach but may require upfront investment in technology and infrastructure. Cost-effectiveness analyses should be conducted to assess potential savings from reduced smoking-related diseases and increased QALYs, thereby assisting policymakers in resource allocation and justifying funding for smoking cessation as part of LCS. Multiple funding models—public health systems, private insurers, and non-governmental organizations (NGOs)—may be involved in financing these interventions. Additionally, a mix of public and private funding, potentially including "polluter pays" schemes involving tobacco companies, may be necessary to ensure sustainability. The UK model, in which LCS is incorporated into a "Lung Health Check," has garnered considerable interest and success; however, its results require confirmation in countries across the EU27 with different healthcare settings (e.g., where mobile CT scanners are not available) [38].

Conclusion

This survey highlights the diverse approaches and challenges in integrating smoking cessation interventions with LCS programs, underscoring the importance of structured, accessible, and evidence-based strategies. The survey finally gives a snapshot of the challenges of implementing a standard approach in integrating SSS and LCS across the EU27 and identify the following key areas for further research: use of cytisinicline as alternative to NRT, the intensity of non-pharmacological interventions, including the use of smartphone apps to increase motivation, and the standardization of the definition of quit rate and ways to validate the latter by tele-contact.

The integration of smoking cessation programs into LCS initiatives in Europe is vital for reducing the burden of lung cancer and improving public health outcomes. By offering pharmacotherapy and personalized behavioral interventions at key time points during the screening process, it is possible to significantly increase quit rates and reduce the future incidence of lung cancer and other smoking-related diseases. However, achieving these goals requires careful planning, adequate funding, and the implementation of evidence-based approaches to ensure that both smoking cessation and LCS are accessible, effective, and cost-efficient. Optimally integrating smoking cessation into LCS programs holds the potential not only to save lives but also to reduce future healthcare costs.

In summary, the following recommendations can be made regarding integration SSS to an LCS program:

- Both services should closely collaborate and preferably be co-located at the screening facility with immediate referral at the time of the initial LDCT
- Referring currently smoking participants to the SSS is self-evident unless they prefer to opt-out
- The SSS offers a combination of pharmacotherapy and behavioral intervention in different sessions

- Succes is measured at short (4 weeks – 6 months) and long term (1 year) and relapse prevention is part of the SSS

Conflict of Interest Statement

JvM and TS receive an institutional grant from the EuCanScreen project HA, ZC, JN, WR and MV have no disclosures

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Disclaimer: Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor the granting authority can be held responsible for them.

Supplementary Appendix 1

Survey Questions

1.Are you integration a structured smoking cessation intervention to your lung cancer screeningproject?

(Structured means that all current smokers in the screening project can/must enroll in a protocolized, evidence-based comprehensive smoking cessation intervention.)

- YES
- NO
- N/A

2. If your answer is 'NO', what kind of smoking cessation intervention are you proposing? *(Select all that apply.)*

- Referral to healthcare professionals (GP, pharmacist, psychologist, smoking nurse, telephone counseling line, etc.)
- Dealer's choice based on participant preference
- Brief written or oral advice
- None specifically
- Not applicable

3. If your answer is 'YES', which are the components of your structured smoking cessation intervention? *(Select all that apply.)*

- Face-to-face behavioral therapy (group or individual) by dedicated healthcare professionals
- Over-the-counter nicotine substitution (e.g., patches, gum, spray, lozenges, vaping)
- Non-face-to-face counseling (via app, video, podcast, website, SMS, etc.)
- Other drugs (e.g., bupropion, varenicline, cytisine, etc.)
- Not applicable

4. If your answer is 'YES', do you follow an opt-in or opt-out model?

- Opt-in model
- Opt-out model
- N/A

5. When does inclusion in your smoking cessation program start relative to lung cancer screening? *(Select all that apply.)*

- Before
- During
- After
- Indifferent

6. Are you including participants who have quit smoking within the past 6 months for relapse prevention?

- YES
- NO
- N/A

7. When do you measure quit success? *(Select all that apply.)*

- After 3 months
- After 6 months
- After 1 year

8. How do you measure/confirm abstinence from smoking?

- Only self-reported
- Self-reported plus CO validation
- Self-reported plus biochemical validation (e.g., cotinine in saliva, urine)
- N/A

9. Who measures quit success at the proposed follow-up time point? *(Select all that apply.)*

- A member/investigator of the lung cancer screening program
- Another physician involved in smoking cessation not related to the screening program
- Another non-physician involved in smoking cessation not related to the screening program
- N/A

10. How do you report your quit rate?

- Point prevalence at a given time point (optionally, plus 7 days prior)
- Continuous over a given period
- Both

- N/A

11. How do you calculate the quit rate? *(Please define the denominator used.)*

12. Does your smoking cessation program provide any free medication to participants?

- NO
- YES, nicotine substitution in any form (including vaping)
- YES, other approved drug (bupropion, varenicline, cytisine)
- YES, investigational drug

13. Do participants in your lung cancer screening project have to have quit smoking or adhere to a smoking cessation program before undergoing a CT scan?

- YES
- NO

14. What is the approach for participants not motivated to quit smoking? *(Select all that apply.)*

- Delay the CT scan until after quitting
- Enhance motivation by motivational interviewing (e.g., the 5 R's)
- Advise the use of NRT
- Other
- N/A

15. What target quit rate do you aim for in your coupled smoking cessation project?

- 10–20%
- 21–30%
- 31–40%
- 41–50%
- 51%
- N/A

16. Do participants receive any financial incentive for quitting?

- YES

- NO

17. Is any component of your smoking cessation program reimbursed or covered by: *(Select all that apply.)*

- Social security
- Private health insurance
- Health authorities
- Project sponsor
- Pharma industry
- No reimbursement
- NA

18. What is the approximate out-of-pocket cost for your smoking cessation program?

- < € 50
- € 50–€ 100
- € 101–€ 150
- € 151–€ 200
- € 200
- None
- N/A

Supplementary Appendix 2: Countries and Lung Cancer Screening Programs Participating in this Survey

Belgium : ZORALCS/TAMIRO-STOP (https://zoralcs.be/)

Czechia : National Lung cancer screening programme

Finland : EUCanScreen pilot in Finland (www.eucanscreen.eu)

Low dose Ct screening for lung cancer combines to different smoking cessation methods (LDCT-SC-FI)

Hungary : HUNCHEST 3 International: SOLACE (www.solace.eu)

4 IN THE LUNG RUN TRIAL (https://www.i-dna.org/4-in-the-lung-run/)

Ireland : Beaumont RCSI Irish Cancer Society Lung Health Check Pilot

Italy : Rete Italiana Screening Polmonare (RISP) CCM-ITALUNG 2 Pilot

Norway : TIDL Nordvästan

Poland : WWRP MOLTEST II

Pomorski pilatozowy Program Badan Przesiewowycch Raca Pluca

Slovenia : LUKA

Spain : CASSANDRA (http://www.proyectocassandra.com/proyecto.php)

Sweden : Swedish implementation study of LDDTLC screening

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