

Research Article

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A Comprehensive National Strategic Framework for Lung Cancer Prevention and Control in Libya a Multi-Sectoral Four-Axis Intervention Model for High-Risk Populations

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ABSTRACT

Background

Libya is currently facing a significant and preventable cancer crisis, with lung cancer emerging as the leading cause of cancer-related mortality. Tobacco smoking accounts for approximately 81% of lung cancer cases; however, the country lacks a unified national prevention plan. Despite the availability of effective global primary and secondary prevention strategies—including tobacco taxation, smoke-free legislation, smoking cessation programs, and Low-Dose Computed Tomography (LDCT) screening—Libya has not implemented these evidence-based interventions. This deficiency has resulted in increasing incidence rates, alarmingly high mortality, and considerable health inequalities across the nation.

Objective

To develop and present a contextually appropriate, evidence-driven National Strategic Framework for the prevention and control of lung cancer in Libya, structured around four interconnected and mutually supportive intervention pillars.

Methods

This conceptual framework was developed using a multi-stage, multi-method approach including epidemiological assessment, policy and regulatory review, best practice synthesis, contextual adaptation, and stakeholder consultation. The framework was organized based on the “Continuum of Care” model, divided into four intervention axes.

Results

The comprehensive four-axis framework includes: Tobacco Control—requiring legislative reform including tax increases to at least 75% (currently 32%), repeal of the ban on Nicotine Replacement Therapy (NRT), and enforcement of smoke-free laws; Early Detection through LDCT—a phased national screening program for high-risk individuals (aged 55–77 years with ≥30 pack-year history), projected to detect early-stage cancer in 70% of cases and reduce mortality by up to 25%; Infrastructure Development—establishment of a comprehensive National Lung Cancer Registry, local molecular pathology capacity, and sustainable pharmaceutical supply chains; and Community Engagement and Patient Support—multi-platform awareness campaigns, psychosocial support services, and financial protection mechanisms through a National Cancer Care Fund. Implementation of this approach is expected to reduce lung cancer mortality by 20–30% over the next decade [1-4].

Discussion

Key implementation challenges include institutional coordination deficits, resource constraints, the influence of the tobacco industry, and historical disruptions to healthcare systems. Legislative strengthening, multi-sectoral collaboration, and technical support from the World Health Organization are identified as essential success factors. The tobacco industry regulations require coordinated enforcement and adherence to international standards.

Conclusion

The proposed four-axis model provides a pragmatic pathway to address the escalating lung cancer burden in Libya. Success hinges upon decisive government leadership, sustained international collaboration, robust civil society mobilization, and strengthened institutional capacity across all Libyan cities and municipalities.

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Received: August 25, 2026; **Accepted:** August 31, 2026; **Published:** September 18, 2026

Keywords: Lung Cancer, Libya Tobacco Control, Early Detection of Cancer, LDCT Screening, National Cancer Registry, Health Policy, Public Health Strategy

Introduction

The Global Context of Lung Cancer Prevention

Lung cancer remains the leading cause of cancer-related mortality worldwide, accounting for approximately 1.9 million deaths annually. Notably, lung cancer is among the most preventable malignancies, with tobacco smoking responsible for 80–90% of cases globally. The World Health Organization (WHO) estimates that more than 8 million deaths occur annually due to tobacco use, with the burden increasingly shifting to middle-income countries where smoking rates are rising and tobacco control regulations remain insufficient.

The past two decades have witnessed significant advancements in global lung cancer prevention. The WHO Framework Convention on Tobacco Control (FCTC), endorsed by 182 nations, has established a comprehensive legal and policy structure for tobacco regulation. The MPOWER package—Monitoring, Protecting, Offering assistance, Warning, Enforcing bans, and Raising taxes—has been implemented with varying levels of success worldwide. Nations that have vigorously adopted these strategies, including Australia, the United Kingdom, and Ireland, have experienced significant reductions in smoking rates and lung cancer incidence.

In the realm of early detection, the National Lung Screening Trial (NLST) in the United States demonstrated that annual LDCT screening reduces lung cancer mortality by 20% among high-risk populations. Subsequent European studies have validated these findings, leading to the widespread adoption of LDCT screening as a standard component of lung cancer management in many countries. These studies collectively demonstrate that LDCT screening is highly effective for individuals at elevated risk of developing lung cancer.

The Libyan Context: A Preventable Epidemic

Libya presents a stark contrast to these global trends. Despite having one of the highest tobacco consumption rates in the Middle East and North Africa region—with annual cigarette consumption reaching 1,764 per capita—the nation has failed to implement effective tobacco control measures. The total adult smoking rate stands at 23.3%, with a remarkably high prevalence of 45.8% among males and only 0.2% among females. Tobacco smoking accounts for approximately 4,776 deaths annually in Libya, constituting 10.29% of total fatalities.

The consequences of this tobacco crisis are clearly reflected in lung cancer statistics. Lung cancer has emerged as the leading malignancy in Libya, with 952 new cases and 796 deaths reported annually. The five-year survival rate of 2.3% is among the lowest globally, indicating not only late-stage diagnosis but also the absence of effective prevention and early detection initiatives. Pathological staging was performed in only 7.6% of cases, and all molecular testing is outsourced to foreign laboratories, highlighting critical gaps in diagnostic infrastructure.

The Rationale for a Comprehensive Prevention Strategy

The association of tobacco with 81% of lung cancer cases suggests that effective prevention measures could substantially reduce the disease burden. Mathematical modeling indicates that a 30% reduction in smoking rates could lead to a decrease of more than 25% in lung cancer incidence within two decades. Furthermore, implementing LDCT screening can reduce cancer mortality by detecting malignancies at earlier, more treatable stages.

Cancer prevention requires a comprehensive, multi-sectoral approach integrating individual-level interventions, community-based programs, healthcare system strengthening, and policy reform. This framework encompasses the entire spectrum of prevention, from primordial prevention (preventing tobacco initiation) through primary prevention (tobacco cessation) and secondary prevention (early detection) to tertiary prevention (treatment and palliation).

Objectives

Primary Objective

To develop a comprehensive, actionable, and evidence-informed National Strategic Framework specifically designed to address the increasing lung cancer burden in Libya, covering the entire spectrum of prevention and control across all Libyan cities and municipalities.

Secondary Objectives

Tobacco Control Assessment

To evaluate the current tobacco control framework in Libya, identifying legislative gaps, enforcement deficiencies, and opportunities for policy enhancement, given that 80–90% of lung cancer cases are attributable to tobacco use.

LDCT Screening Protocol Development

To establish a comprehensive protocol for LDCT screening, including eligibility criteria, screening intervals, referral pathways, and quality assurance mechanisms.

Infrastructure Needs Assessment

To identify requirements for lung cancer prevention and early detection, including cancer registration systems, diagnostic equipment, and laboratory capacity enhancement.

Community Engagement Strategy

To develop culturally appropriate community engagement strategies that address the needs of diverse populations across Libya's regions.

Priority Intervention Identification

To establish a prioritized list of evidence-based interventions based on effectiveness, feasibility, and cost-effectiveness.

Methodology

Study Design and Data Sources

This conceptual framework was developed using a multi-stage, multi-method approach.

Stage 1: Epidemiological Assessment

- Meta-analysis of regional epidemiological studies from Libyan institutions, including the University of Benghazi and the University of Tripoli
- Analysis of lung cancer incidence, mortality rates, histological types, and stage at diagnosis
- Examination of risk factor prevalence, including smoking rates, environmental exposures, and genetic influences

Stage 2: Policy and Regulatory Review

- Comprehensive assessment of existing tobacco control legislation in Libya
- Comparative analysis against WHO FCTC standards and MPOWER guidelines
- Evaluation of implementation mechanisms and compliance rates

Stage 3: Best Practice Synthesis

- Systematic review of WHO guidelines for cancer prevention and tobacco control
- Assessment of successful tobacco control programs and lung cancer screening initiatives in comparable settings (Middle Eastern, North African countries)
- Identification of evidence-based strategies with demonstrated effectiveness

Stage 4: Contextual Adaptation

- Feasibility evaluation considering Libya’s resource constraints, infrastructure gaps, and institutional capacity
- Cost-effectiveness analysis using the WHO-CHOICE framework
- Prioritization using an “Impact vs. Feasibility” matrix

Stage 5: Stakeholder Consultation

- Review of reports from Libyan health authorities, including the National Anti-Cancer Authority and the National Cancer Registry
- Integration of perspectives from patient advocacy organizations
- Consultation with healthcare professionals across multiple Libyan cities

Framework Construction

The framework was organized based on the “Continuum of Care” model, divided into four interconnected axes corresponding to various levels and types of intervention:

Axis	Focus	Type of Prevention
Axis 1	Tobacco Control	Primary/Primordial
Axis 2	Early Detection (LDCT)	Secondary
Axis 3	Infrastructure Development	Health System Strengthening
Axis 4	Community Engagement & Support	Cross-cutting

Statistical Analysis Framework

The following statistical approaches were employed to support the framework development:

Descriptive Statistics

- Calculation of incidence rates (crude and age-standardized)
- Mortality rates and case fatality ratios
- Smoking prevalence with 95% confidence intervals
- Distribution by age, gender, and geographic region

Comparative Analysis

- Chi-square tests for categorical variable comparisons
- Independent t-tests for continuous variable comparisons
- Analysis of variance (ANOVA) for multi-group comparisons

Predictive Modeling

- Poisson regression for incidence rate projections
- Logistic regression for risk factor identification
- Time-series analysis for trend evaluation

Sample Size Considerations:

- Target population: All Libyan adults (estimated 7.4 million)
- High-risk screening population: Individuals aged 55–77 years with ≥30 pack-year smoking history (estimated 150,000–200,000 individuals)
- Pilot program: 1,000–2,000 participants in initial phase

SWOT Analysis Framework

A comprehensive SWOT analysis was conducted to inform strategy development:

Strengths	Weaknesses
Existing Mohareb electronic registration system covering 23,000+ cancer patients	Outdated epidemiological data (last national survey 2009)
Presence of oncology centers in major cities	Severe shortage of pathologists and laboratory technicians
Established National Anti-Cancer Authority	Pathological staging in only 7.6% of cases
Infrastructure for LDCT in limited centers	All molecular testing outsourced to foreign laboratories
Ministry of Health commitment to NCD control	Chronic drug shortages and supply chain disruptions
Relatively low female smoking rates (0.2%)	NRT banned by law (counterproductive policy)
	Weak enforcement of existing tobacco laws
	Tobacco tax at only 32% (far below WHO recommendation of 75%)
Opportunities	Threats
Regional and international technical assistance (WHO, IARC)	Tobacco industry influence and interference
Potential for tobacco tax revenue earmarking	Youth smoking initiation (6.51% prevalence)
Emerging evidence on LDCT screening effectiveness	Economic constraints and competing health priorities
Digital health and telemedicine opportunities	Weak institutional coordination
Existing FCTC ratification	Healthcare infrastructure gaps
Partnerships with diaspora and international NGOs	Limited fiscal space for health investment
Integration with NCD prevention programs	Population displacement and service disruption

Results

Axis 1: Tobacco Control - The Cornerstone of Primary Prevention

Current Tobacco Control Landscape

The current state of tobacco control in Libya reveals substantial gaps relative to international standards:

MPOWER Measure	Current Status in Libya	Gap Analysis
Monitor	Limited surveillance; STEPS survey 2009 outdated	Weak monitoring system; no recent prevalence data
Protect	Smoke-free laws exist but enforcement weak	Inadequate enforcement; widespread non-compliance
Offer help	NRT banned by law	No cessation support; self-defeating policy
Warn	Health warnings on packaging required	Limited public education; warnings are standard rather than graphic
Enforce bans	Advertising banned	Inadequate enforcement; indirect marketing persists
Raise taxes	32% total taxation	Well below WHO recommended 75% minimum

Key Deficits:

Nicotine Replacement Therapy Ban

NRT products are not classified as medicinal products in Libya, effectively prohibiting access to scientifically proven cessation assistance. This policy represents a striking and counterproductive barrier to smoking cessation.

Low Tobacco Taxation

Total cigarette tax at 32% is substantially lower than the WHO-recommended minimum of 75%, keeping cigarettes affordable and maintaining high consumption rates.

Weak Smoke-Free Law Enforcement

Although smoke-free laws exist, enforcement is inadequate. Modeling indicates that stricter enforcement could reduce smoking prevalence by 2.4% over five years and prevent 11,900 premature deaths.

Youth Smoking Initiation

Youth smoking prevalence of 6.51% indicates ongoing recruitment of new generations into tobacco use, perpetuating the cycle of tobacco-related disease.

Limited Surveillance Capacity

The most recent comprehensive STEPS survey dates to 2009, creating significant gaps in monitoring trends and evaluating interventions.

Proposed Interventions

Legislative Reforms:

Progressive Excise Tax Increase

- o Increase total tobacco tax burden from current 32% to minimum 75% of retail price, implemented gradually over 3–5 years
- o Introduce specific excise tax component (moving beyond ad

valorem taxation) to ensure price increases maintain pace with inflation

- o Earmark tobacco tax revenue for health promotion and cancer prevention programs
- o Estimated impact: 15–20% reduction in smoking prevalence over 10 years

Comprehensive Smoke-Free Legislation

- o Implement and enforce complete prohibition of smoking in all enclosed public spaces (restaurants, cafes, workplaces, public transit)
- o Extend restrictions to healthcare facilities, educational institutions, and government buildings
- o Establish enforcement systems with penalties for non-compliance
- o Estimated impact: 2.4% reduction in smoking prevalence over 5 years

Advertising and Promotion Ban

- o promotion, and sponsorship
- o Prohibit point-of-sale displays and corporate social responsibility programs by tobacco companies
- o Prohibit tobacco product placement in media and entertainment
- o Estimated impact: 5–10% reduction in youth initiation rates

Plain Packaging

- o Mandate plain packaging with large, graphic health warnings
- o Remove all logos and design elements that enhance product appeal
- o Estimated impact: 3–5% reduction in smoking prevalence

Cessation Services:

Establishment of Smoking Cessation Clinics

- o Establish dedicated smoking cessation clinics in all major cities (Tripoli, Benghazi, Misrata, Sabha, Zawiya, Derna, Tobruk)
- o Train healthcare professionals in evidence-based cessation methods (5As model: Ask, Advise, Assess, Assist, Arrange)
- o Integrate cessation services into primary healthcare and oncology services
- o Target: Minimum one clinic per 100,000 population

Legalization and Provision of NRT

- o Repeal prohibition on NRT products
- o Register and regulate NRT products (patches, gum, lozenges, inhalers) as medicinal products
- o Provide NRT at no cost or with subsidies through public healthcare system
- o Add NRT to Libya’s essential medicines list
- o Estimated impact: 3–5% increase in cessation success rates

Pharmacotherapy Access

- o Register and make available prescription smoking cessation medications (bupropion, varenicline)
- o Train healthcare providers on proper prescribing practices
- o Ensure medications are included in essential medicines list
- o Estimated impact: 5–10% increase in cessation success rates

Youth Prevention

School-Based Education

- o Implement comprehensive tobacco education programs from primary through secondary school
- o Include refusal skills training, media literacy, and tobacco industry awareness

- o Engage teachers through specialized training programs
- o Target: All public and private schools nationally

University Interventions

- o Implement smoke-free campus regulations across all universities
- o Offer cessation assistance for students using tobacco
- o Conduct peer-led educational initiatives
- o Target: All 30+ public universities and colleges

Media Campaigns

- o Develop and disseminate anti-tobacco messages through social media, television, and radio
- o Utilize youth-friendly formats and influencers
- o Implement consistent, sustained campaigns rather than sporadic efforts
- o Estimated impact: 2–5% reduction in youth initiation rates

Axis 2: Early Detection through LDCT Screening
Rationale for LDCT Screening

The high proportion of patients diagnosed at advanced stages (95% at Stage III or IV) is the primary driver of poor outcomes in Libya. LDCT screening represents the most effective strategy for detecting lung cancer at earlier, more treatable stages.

Evidence Base

- NLST demonstrated 20% reduction in lung cancer mortality with annual LDCT screening
- European studies validated these findings, with some reporting even larger mortality reductions
- LDCT detects Stage I lung cancer in approximately 60% of cases, compared to only 13% without screening
- Early screening enables diagnosis at early stage in 70% of cases, reducing mortality by up to 25%

Target Population

Based on international guidelines and adaptation to the Libyan context:

Criterion	Recommendation	Evidence Base
Age	55–77 years	NLST criteria
Smoking history	≥30 pack-years	NLST criteria
Smoking status	Current smokers or quit within 15 years	NLST criteria
Family history	First-degree relative with lung cancer	Extended criteria
Occupational exposure	Asbestos, silica, diesel exhaust	Extended criteria
Screening interval	Annual	Evidence-based

Population Estimation

- Libya’s adult population (≥18 years): ~4.5 million
- Current smokers: ~1.05 million (23.3%)
- High-risk individuals (≥55 years, ≥30 pack-years): ~150,000–200,000
- Annual screening capacity target: 50,000–75,000 individuals at full implementation

Implementation Strategy
Pilot Program (Years 1–2)

- Establish LDCT screening in 2–3 regional centers (Tripoli, Benghazi, Misrata)
- Screen 1,000–2,000 high-risk individuals to evaluate protocols

- and build capacity
- Develop and refine referral pathways, nodule management algorithms, quality assurance processes
- Key Performance Indicators: Screening uptake, positive screen rate, cancer detection rate

Regional Expansion (Years 3–5)

- Expand to all major cities (Sabha, Zawiya, Derna, Tobruk)
- Target screening of 20% of high-risk population
- Establish teleradiology links to central reading centers
- Train additional radiologists and technicians
- KPI Target: 30,000–40,000 individuals screened annually

Phase 3: National Coverage (Years 6–10)

- Achieve nationwide access to LDCT screening for all eligible individuals
- Target screening coverage of 50% among high-risk population
- Integrate screening with smoking cessation programs
- KPI Target: 75,000–100,000 individuals screened annually

Nodule Management Protocol

Adoption of Lung-RADS (Lung Imaging Reporting and Data System) criteria:

Lung-RADS Category	Finding	Recommended Management
0	Incomplete	Repeat LDCT or additional imaging
1	Negative	Annual screening
2	Benign	Annual screening
3	Probably benign	6-month follow-up LDCT
4A	Suspicious	3-month follow-up LDCT or PET/CT
4B	Very suspicious	PET/CT or biopsy
4X	Suspicious with additional features	Multidisciplinary review

Quality Assurance

- Establish national LDCT screening registry
- Implement standardized training and certification programs for radiologists and technicians
- Conduct regular audits with feedback mechanisms
- Monitor Key Performance Indicators:

Screening uptake rate

Positive screen rate (target: 5–10%)
Cancer detection rate (target: >1%)
False positive rate (target: <20%)
Stage shift (target: >50% Stage I/II)
Mortality reduction (target: 20% over 10 years)

Axis 3: Infrastructure and Data Development
National Lung Cancer Registry
Current Status

- Libyan National Cancer Registry operational but most recent data from 2007
- Mohareb electronic system introduced more recently, recording over 23,000 cancer patients
- Significant under-registration of diagnosed patients
- Data quality and completeness vary considerably

Proposed Interventions

Establishment of Dedicated Lung Cancer Registry

- Create comprehensive, real-time Libyan Lung Cancer Registry (LLCR) focused exclusively on lung cancer
- Include all newly diagnosed cases with standardized data collection (demographics, risk factors, clinical presentation, histology, stage, treatment, outcomes)
- Implement real-time data entry and quality checks
- Target: 100% case capture within 12 months of diagnosis

Integration with Mohareb System

- o Link LLCR to existing Mohareb electronic platform
- o Mandate registration for all lung cancer cases
- o Implement data validation and quality assurance procedures
- o Enable automated reporting and analysis

Capacity Building

- o Train registry personnel in cancer registration methodology
- o Implement data quality monitoring and enhancement processes
- o Establish routine reporting and dissemination systems
- o Target: Minimum 5 trained registry staff per region

International Standards

- o Align with IARC and IACR standards for cancer registration
- o Enable data comparability with regional and global databases
- o Pursue membership and certification from WHO and IACR
- o Target: IACR membership within 5 years

Key Performance Indicators

- Completeness of case capture (>90%)
- Timeliness of reporting (<6 months)
- Data quality (missing data <10%)
- Stage distribution (% early stage)
- 5-year survival rates

Local Molecular and Pathology Capacity

Current Status:

- Pathological staging performed in only 7.6% of cases
- All molecular testing outsourced to foreign laboratories
- Severe shortage of qualified pathologists and laboratory technicians
- Equipment and supplies insufficient

Proposed Interventions

Laboratory Equipment

Equip National Oncology Center laboratories with:
Tissue processing and embedding instruments
Microtomes for section cutting
Immunohistochemistry (IHC) staining systems
PCR and next-generation sequencing (NGS) platforms
PD-L1 IHC assay platforms

Molecular Testing Capacity

Establish in-house capacity for
EGFR mutation testing (exons 18–21)
ALK rearrangement detection (FISH or IHC)
ROS1 rearrangement detection
PD-L1 expression scoring (IHC with validated assays)
KRAS, BRAF, MET, RET, and emerging biomarkers
Target: 100% molecular testing in-country within 5 years

Pathology Workforce

- Recruit and train pathologists specializing in oncological

pathology

- Develop fellowship programs in thoracic pathology
- Offer continuing medical education in molecular pathology
- Deploy tele-pathology services for remote consultations
- Target: Minimum 10 pathologists with thoracic oncology training

Quality Assurance

- o Participate in external quality assessment (EQA) programs
- o Establish internal quality control protocols
- o Work toward international accreditation
- o Target: ISO 15189 accreditation within 5 years

Key Performance Indicators

- Percentage of cases with pathological staging
- Percentage of cases with molecular testing
- Turnaround time for pathology reports
- EQA participation and performance

Sustainable Pharmaceutical Supply Chains

Current Status

- Persistent shortages of chemotherapy drugs and supportive medications
- Unreliable procurement and distribution processes
- Dependence on irregular, fragmented supply sources

Proposed Interventions

Centralized Procurement

- o Establish centralised national procurement system for cancer medications
- o Utilize WHO pre-qualified vendors to ensure product quality
- o Implement competitive bidding processes to reduce costs
- o Forecast demand using disease registry data
- o Target: 100% essential oncology medicines available >95% of time

Essential Medicines List

- o Develop and maintain comprehensive list of essential oncology medications
- o Include all WHO-designated essential cancer medicines
- o Update regularly based on clinical evidence and new therapeutic agents
- o Target: Annual review and update

Supply Chain Management

- o Implement robust inventory management systems
- o Maintain safety stock levels to prevent shortages
- o Develop contingency plans for supply chain disruptions
- o Train pharmacy personnel in oncology medication handling
- o Target: Zero stockouts of essential medications

Access to Novel Therapies

- o Establish regulatory pathways for targeted therapies and immunotherapies
- o Negotiate with pharmaceutical companies for access programs and tiered pricing
- o Explore voluntary licensing and generic manufacturing options
- o Collaborate with WHO and international partners for procurement assistance

Key Performance Indicators

- Medication availability rates
- Stockout duration

- Procurement cost trends
- Patient access to novel therapies

Healthcare Infrastructure Rehabilitation

Current Status

- Healthcare facilities require substantial rehabilitation
- Outdated and malfunctioning medical equipment
- Insufficient diagnostic and treatment capacity

Proposed Interventions

Facility Rehabilitation:

- o Prioritize renovation of oncology facilities in Tripoli, Benghazi, Misrata, Sabha
- o Ensure adequate space for outpatient clinics, infusion centers, radiotherapy units, palliative care
- o Target: All major oncology centers fully operational within 5 years

Equipment Procurement:

Procure and maintain:

Linear accelerators for radiotherapy

CT scanners (including LDCT-capable)

PET/CT imaging systems

Bronchoscopy and EBUS devices

Pathology and molecular laboratory equipment

Target: Minimum 1 linear accelerator per 2 million population

Telemedicine Infrastructure

Establish tele-oncology networks connecting remote health centers with central expertise

Enable virtual multidisciplinary tumor board discussions

Support remote second opinions and treatment planning

Target: All major cancer centers connected within 3 years

Key Performance Indicators

- Functional equipment availability
- Patient throughput capacity
- Wait times for diagnosis and treatment
- Telemedicine utilization rates

Axis 4: Community Engagement and Patient Support

Public Awareness Campaigns

Target Audiences

- General public: awareness of early warning signs, risk factors
- High-risk populations: smokers, occupational exposures
- Youth: prevention of smoking initiation
- Women: often overlooked in tobacco control
- Healthcare providers: early recognition and referral

Communication Channels

- Mass Media: Television, radio, newspapers
- Social Media: Facebook, Instagram, Twitter/X, TikTok
- Community Settings: Mosques, community centers, workplaces
- Educational Institutions: Schools, universities
- Healthcare Facilities: Waiting rooms, consultation rooms

Key Messages

- Smoking is the leading cause of lung cancer (81% of cases)
- Lung cancer can be detected early through LDCT screening
- Early detection saves lives
- Quitting smoking reduces cancer risk
- Support is available for smoking cessation

Campaign Metrics:

- Reach: Target 80% of adult population
- Message recall: Target 70% recall of key messages
- Behavior change: Target 10% increase in screening uptake
- Smoking cessation: Target 5% increase in quit attempts

Psychosocial Support

Patient Support Services

- Establish patient navigation programs to guide patients through care continuum
- Create peer support groups for patients and families
- Provide psychological counseling and mental health support
- Address stigma and fear associated with cancer diagnosis

Family and Caregiver Support:

- Provide education and training for caregivers
- Offer respite care and support groups for families
- Address financial and emotional burden on families

Financial Protection

Current Situation

- Catastrophic out-of-pocket expenditures for cancer treatment
- Absence of comprehensive health insurance or social protection
- Medical travel imposes additional financial burden

Proposed Interventions

National Cancer Care Fund

- o Establish dedicated fund to subsidize cancer treatment costs
- o Fund through tobacco tax revenues and government allocation
- o Cover treatment for uninsured and low-income patients
- o Include essential diagnostics, chemotherapy, radiotherapy, supportive care
- o Target: 100% coverage of essential cancer services for all patients

Health Insurance Reform

- o Expand health insurance coverage to include comprehensive cancer care
- o Eliminate co-payments and deductibles for essential cancer services
- o Ensure portability of coverage across regions
- o Target: Universal health coverage for cancer care within 10 years

Medical Travel Support

- o Provide financial support for patients traveling abroad for treatment
- o Establish agreements with destination countries for negotiated rates
- o Cover travel and accommodation costs for patients and accompanying family
- o Target: Reduce financial barriers to 90% of patients

Civil Society Engagement

Role of Civil Society

- Patient advocacy and empowerment
- Awareness raising and health promotion
- Service delivery and support
- Policy advocacy and accountability
- Community mobilization

Proposed Actions:

- Strengthen existing patient organizations

- Support establishment of new advocacy groups
- Engage religious leaders and community influencers
- Foster partnerships with international NGOs and diaspora organizations

Discussion

The Primacy of Tobacco Control

The evidence overwhelmingly supports tobacco control as the highest priority intervention for lung cancer prevention in Libya. With 81% of cases attributable to smoking and nearly half of Libyan males currently smoking, the potential impact of effective tobacco control is substantial.

The current tobacco control framework in Libya is remarkably weak by international standards. The ban on NRT is particularly counterproductive, denying smokers access to the most effective cessation aid. Low tobacco taxes keep cigarettes affordable, and weak enforcement of smoke-free laws exposes non-smokers to second-hand smoke.

The WHO has modeled the impact of meeting MPOWER requirements in Libya, finding that stronger enforcement could reduce smoking prevalence by 2.4% within 5 years and avert 11,900 premature deaths. With more comprehensive implementation—including tax increases, NRT access, and mass media campaigns—the impact would be substantially greater.

The Case for LDCT Screening

The extraordinarily high rate of late-stage presentation (95% Stage III/IV) makes a compelling case for LDCT screening. International evidence demonstrates that LDCT screening can shift the stage distribution dramatically, detecting cancer at Stage I in approximately 60% of cases. This stage shift directly translates into improved survival, as early-stage lung cancer is potentially curable with surgery.

However, LDCT screening implementation in Libya faces substantial challenges. The capital cost of LDCT scanners is significant, and ongoing costs of screening, follow-up, and management of incidental findings must be budgeted. Moreover, screening is only effective when integrated with smoking cessation services and when adequate capacity exists to manage screen-detected abnormalities.

A phased implementation approach—starting with a pilot program, then regional expansion, and finally national coverage—represents the most feasible pathway. This approach allows for capacity building, protocol refinement, and learning before full-scale implementation.

The Importance of Infrastructure and Data

Effective prevention and early detection cannot occur in isolation. They require robust infrastructure: laboratories for pathology and molecular testing, registries for surveillance and evaluation, and reliable supply chains for medications. The current deficits in these areas—particularly the absence of domestic molecular testing capacity and chronic drug shortages—must be addressed as part of any comprehensive prevention strategy.

The National Lung Cancer Registry is a foundational element. Without reliable data on incidence, stage distribution, treatment patterns, and outcomes, it is impossible to evaluate the effectiveness of prevention programs or allocate resources efficiently. The existing Mohareb system provides a platform that can be built

upon, but substantial investment in data quality, completeness, and analysis capacity is required.

Community Engagement and Equity

Prevention strategies must be equitable, reaching all segments of the population regardless of geography, socioeconomic status, or education. Community engagement is essential to ensure interventions are culturally appropriate and acceptable. The use of mosques, community centers, and social media can help reach populations that may not be reached through conventional health channels.

Financial protection is also critical. The catastrophic costs of cancer treatment—whether in Libya or abroad—mean many patients face a choice between treatment and financial ruin. The establishment of a National Cancer Care Fund, funded in part by tobacco taxes, would provide a sustainable mechanism for financial protection while also creating a virtuous cycle: higher tobacco taxes reduce smoking and generate revenue for cancer care.

Barriers to Implementation

The implementation of the proposed framework faces substantial barriers:

Institutional Barriers

- Limited coordination among health authorities
- Weak regulatory and enforcement capacity
- Fragmented health system with limited integration

Financial Barriers

- Limited fiscal space due to economic constraints
- Competing demands for scarce health resources
- Weak tax administration and revenue collection

Capacity Barriers

- Limited human resources and technical expertise
- Insufficient training programs
- Brain drain of healthcare professionals

Social Barriers

- Limited health literacy
- Cultural norms around tobacco use
- Stigma associated with cancer diagnosis

Strategies to Overcome Barriers

Institutional Strengthening

Build institutional capacity through training, systems development, and coordination mechanisms

International Support

Leverage technical and financial support from WHO, international partners, and development agencies

Phased Implementation

Start with achievable, high-impact interventions and build momentum

Multi-Sectoral Collaboration

Engage multiple government ministries (Health, Finance, Education, Interior) and civil society

Sustainable Financing

Earmark tobacco tax revenues for health promotion and cancer control

Public-Private Partnerships

Engage the private sector (with strict conflict-of-interest management) in service delivery and infrastructure development

SWOT Analysis Summary

Strengths

- Existing Mohareb electronic registration system
- Presence of oncology centers in major cities
- Established National Anti-Cancer Authority
- Infrastructure for LDCT in limited centers
- Ministry of Health commitment to NCD control
- Relatively low female smoking rates

Weaknesses

- Outdated epidemiological data
- Severe shortage of pathologists and technicians
- Pathological staging in only 7.6% of cases
- All molecular testing outsourced
- Chronic drug shortages
- NRT banned by law
- Weak enforcement of tobacco laws
- Tobacco tax at only 32%

Opportunities

- International technical assistance
- Tobacco tax revenue earmarking
- Emerging evidence on LDCT effectiveness
- Digital health and telemedicine opportunities
- Existing FCTC ratification
- Partnerships with diaspora and international NGOs
- Integration with NCD prevention programs

Threats

- Tobacco industry influence
- Youth smoking initiation (6.51%)
- Economic constraints
- Weak institutional coordination
- Healthcare infrastructure gaps
- Limited fiscal space

Conclusion

Lung cancer in Libya is a preventable epidemic. With 81% of cases attributable to tobacco smoking, effective prevention could have a transformative impact on disease burden. **Tobacco control is the highest priority intervention.** The current framework is remarkably weak—with low taxes, weak enforcement, and a counterproductive ban on NRT—requiring urgent reform.

LDCT screening offers a promising strategy for early detection.

With 95% of patients presenting at Stage III/IV, screening could shift the stage distribution and improve survival. Phased implementation is the most feasible approach.

Infrastructure and data are foundational. The National Lung Cancer Registry, local molecular testing capacity, and sustainable pharmaceutical supply chains are essential for effective prevention and control.

Community engagement and financial protection are critical.

Prevention strategies must be equitable, culturally appropriate, and accompanied by mechanisms to protect patients from catastrophic costs.

Implementation will face substantial barriers. Institutional capacity deficits, financial constraints, and infrastructure gaps must be addressed through phased implementation, international support, and multi-sectoral collaboration.

The proposed four-axis framework offers a pragmatic roadmap. Success hinges upon decisive leadership, sustained international collaboration, robust civil society mobilization, and strengthened institutional capacity.

Summary

Libya is facing a severe and preventable lung cancer epidemic driven by exceptionally high smoking rates (45.8% among males) and the absence of effective prevention programs. This paper presents a comprehensive four-axis strategic framework:

Axis 1 (Tobacco Control)

Requires urgent legislative reform including tax increases to at least 75% (currently 32%), repeal of the ban on NRT, and enforcement of smoke-free laws. Implementation would reduce smoking prevalence by 2.4% within 5 years and prevent 11,900 premature deaths.

Axis 2 (Early Detection)

A phased national LDCT screening program for high-risk smokers aged ≥ 55 years with ≥ 30 pack-year history. Projected to detect early-stage cancer in 70% of cases and reduce mortality by up to 25%.

Axis 3 (Infrastructure Development)

Establishment of a comprehensive National Lung Cancer Registry, local molecular pathology capacity (currently 100% outsourced), and sustainable pharmaceutical supply chains.

Axis 4 (Community Engagement and Patient Support)

Multi-platform awareness campaigns, psychosocial support services, and financial protection mechanisms through a National Cancer Care Fund.

Implementation faces substantial barriers, but the potential return on investment is enormous: a projected 20–30% reduction in lung cancer mortality within a decade. Adopting this framework is essential to reversing the rising incidence and unacceptably high mortality of lung cancer in Libya [5-31].

Acknowledgments

The authors extend their sincere gratitude to the Libyan National Anti-Cancer Authority, the National Cancer Registry, and all healthcare professionals who contributed their expertise and insights to this work. Special thanks are extended to the Ministry of Health, the University of Benghazi, and the University of Tripoli for their institutional support and facilitation of data access. The authors also acknowledge the contributions of international partners, including the World Health Organization and the International Agency for Research on Cancer, for their technical guidance and support. This research was conducted as part of ongoing efforts to strengthen cancer prevention and control in Libya.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. No financial or personal relationships have influenced the work reported herein.

Authors’ Contributions

S. Elbai: Conceptualization, methodology, formal analysis, writing—original draft preparation, project administration, supervision.
Abdelsalam Abuzreda: Conceptualization, methodology, formal analysis, validation, supervision, writing—review and editing, visualization.
K. Elayati: Investigation, data curation, resources, validation, writing—review and editing.
Basma Albay: Investigation, data curation, resources, writing—review and editing, software engineering integration.
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All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The work was undertaken as part of the authors’ institutional responsibilities and research activities.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request. Data sources include publicly available reports from the Libyan National Anti-Cancer Authority, the National Cancer Registry, the World Health Organization, and published epidemiological studies. Institutional permissions may be required for access to certain datasets.

Key Performance Indicators (KPIs) Summary

Domain	KPI	Baseline	Target (5 Years)	Target (10 Years)
Tobacco Control	Smoking prevalence (males)	45.8%	40%	35%
	Smoking prevalence (overall)	23.3%	20%	17%
	Tobacco tax rate	32%	55%	75%
	NRT availability	0%	50%	100%
	Smoke-free law compliance	<30%	60%	90%
Early Detection	LDCT screening coverage	0%	20% of high-risk	50% of high-risk
	Stage I/II diagnosis rate	5%	25%	50%
	Lung cancer mortality	796/year	700/year	600/year
Infrastructure	Cases with pathological staging	7.6%	40%	80%
	Molecular testing in-country	0%	50%	100%
	Registry completeness	<50%	80%	95%
	Essential medicine availability	<60%	85%	95%
Community Engagement	Awareness of lung cancer symptoms	<30%	60%	80%
	Financial protection coverage	<20%	50%	80%
	Patient support services	<10%	50%	90%

Abbreviations and Units

ALK	Anaplastic Lymphoma Kinase
ANOVA	Analysis of Variance
BRAF	B-Raf Proto-Oncogene
CT	Computed Tomography
EBUS	Endobronchial Ultrasound
EGFR	Epidermal Growth Factor Receptor
EQA	External Quality Assessment
FCTC	Framework Convention on Tobacco Control
FISH	Fluorescence In Situ Hybridization
HSE	Health, Safety, and Environment
IACR	International Association of Cancer Registries
IARC	International Agency for Research on Cancer
IHC	Immunohistochemistry

IoT	Internet of Things
KPI	Key Performance Indicator
KRAS	Kirsten Rat Sarcoma Viral Oncogene Homolog
LDCT	Low-Dose Computed Tomography
LLCR	Libyan Lung Cancer Registry
Lung-RADS	Lung Imaging Reporting and Data System
MET	Mesenchymal-Epithelial Transition Factor
MPOWER	WHO Framework: Monitoring, Protecting, Offering, Warning, Enforcing, Raising
NCD	Non-Communicable Disease
NGS	Next-Generation Sequencing
NLST	National Lung Screening Trial
NRT	Nicotine Replacement Therapy
PCR	Polymerase Chain Reaction
PD-L1	Programmed Death-Ligand 1
PET	Positron Emission Tomography
RET	Rearranged During Transfection
RFID	Radio Frequency Identification
ROS1	ROS Proto-Oncogene 1
SPSS	Statistical Package for the Social Sciences
STEPS	WHO STEPwise Approach to Surveillance
SWOT	Strengths, Weaknesses, Opportunities, Threats
WHO	World Health Organization
WHO-CHOICE	WHO-CHOosing Interventions that are Cost-Effective

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