

Characteristics and Associated Survival of Patients Diagnosed With Non–Small Cell Lung Cancer in a Designated Lung Cancer Program in Western Kenya

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ABSTRACT

PURPOSE Although lung cancer is a major cause of cancer incidence and mortality worldwide, lung cancer studies in sub-Saharan Africa are scarce. Here, we present outputs from a designated lung cancer program in western Kenya, part of the Multi-National Lung Cancer Control Program, which focused on case finding, diagnosis, and treatment.

METHODS We retrospectively reviewed patients with pathologically confirmed non–small cell lung cancer (NSCLC) enrolled in this program at Moi Teaching and Referral Hospital from January 2018 to December 2022. Clinical data were analyzed using descriptive statistics, Kaplan–Meier methods, and proportional hazards regression model.

RESULTS Two hundred forty-nine patients diagnosed with NSCLC were included with a median age at diagnosis of 61 (IQR, 52–70) years. Most patients were married (n = 177; 71%) and nonsmokers (n = 177; 71%) with 58 (23%) having received tuberculosis treatment and 93 (37%) having Eastern Cooperative Oncology Group (ECOG) performance status (PS) of ≥ 2 . At diagnosis, adenocarcinoma was the prominent histology (n = 187; 75%) along with clinical stage IV (n = 195; 78% stage IV) or unstaged (n = 40; 16%) disease. Most patients received chemotherapy and radiotherapy (n = 176; 71%) with few palliative care referrals (n = 2; 0.8%). The median overall survival (OS) was only 3.7 months (IQR, 2.7–5.4). ECOG PS (3 or 4) and being unstaged were predictors of poor 1-year OS.

CONCLUSION Patients with NSCLC enrolled in this program presented with advanced disease and poor survival. Despite a designated case finding effort, late diagnosis remained common and highlights a need for locally relevant interventions targeting community and provider education as well as innovative diagnostics that can improve early recognition of lung cancer. These interventions must also be paired with access to proven treatments including molecular therapies and palliative care which can extend lung cancer survival.

ACCOMPANYING CONTENT

 Appendix

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INTRODUCTION

Globally, lung cancer is the most common cancer and the leading cause of cancer death with nearly 2.5 million cases and 1.8 million deaths reported in 2022.¹ Lung cancer incidence varies by region with the highest rates found in Micronesia/Polynesia, Western Europe, Eastern Asia, and Northern America.¹ Conversely, the reported incidence of lung cancer across Africa has been low. In Kenya specifically, 903 new lung cancer cases and 822 lung cancer deaths were reported in 2022, making it only the 11th most common

cause of cancer in the country.¹ However, lack of population-based lung cancer registries and screening/early detection programs coupled with advanced disease presentations with high mortality likely contributes to under-recognition and under-reporting of lung cancer cases.^{2,3} Lung cancer incidence rates have been found to depend on a population's exposure to established risk factors such as cigarette smoking, secondhand smoke, indoor/outdoor air pollution, and radon, asbestos, and other occupational exposures.^{4,5} Given a paucity of data in the country, the population at risk of lung cancer in Kenya remains undefined in contrast to

CONTEXT

Key Objective

What are the real-world outcomes of patients with non–small cell lung cancer (NSCLC) who were enrolled in the first designated lung cancer program in western Kenya?

Knowledge Generated

In this study, 249 patients were diagnosed with NSCLC in western Kenya with a median overall survival of only 3.7 months. Advanced stage and poor performance status were the sole predictors of survival in this cohort. Patients also received a significant amount of treatment despite limited survival with 71 % undergoing both chemotherapy and radiotherapy with few palliative care referrals.

Relevance

Here we share outcomes from the first designated lung cancer program in western Kenya. Patients with NSCLC experienced advanced disease and limited survival. This underscores an overwhelming need to integrate locally relevant interventions into this program to diagnose lung cancer earlier and connect patients to proven treatments.

many high-income countries (HIC) where exposure to these known risk factors and age over 50 years have been well characterized and predictive of developing lung cancer.^{6,7} Kenya has a young population with 91% of its 54 million people below age 50 years and a smoking prevalence of 11.1% which is higher than other countries in the region such as Uganda, Nigeria, and Cameroon but similar to the United States.^{8–12} Other risk factors such as indoor/outdoor air pollution and occupational exposures are prominent in Kenya, although they remain understudied in the context of lung cancer.¹³

Unfortunately, the incidence and mortality rates of lung cancer are predicted to dramatically increase worldwide by 2035.¹⁴ With 75% of all cancer deaths expected to occur in low- and middle-income countries (LMICs) by 2030, a significant lung cancer burden is likely to fall on these countries.¹⁵ Furthermore, whereas HIC have generally seen a decline in smoking prevalence, many LMICs are experiencing little decrease or increase in smoking prevalence over recent years.^{9,12} In addition to smoking-related lung cancer, 10%–20% of lung cancer in the United States and up to 40% in certain regions such as East Asia are not smoking-related.^{16–18} Although advances in lung cancer treatment have led to significant improvements in the survival of patients with lung cancer in HIC, these treatment options have remained infrequently available in Kenya and other LMICs and limit lung cancer survival.^{19–22} Thus, improved data across the lung cancer care continuum including identification of risk factors and diagnostic and treatment information in Kenya and other LMICs are needed to inform interventions that can improve lung cancer–related mortality. This study aims to characterize patients diagnosed with non–small cell lung cancer (NSCLC) from diagnosis to treatment as part of a designated lung cancer program in western Kenya, which is the first in this region of the country.

METHODS

Study Setting

In January 2018, the Multi-National Lung Cancer Control Program (MLCCP) was initiated in Kenya, Tanzania, South Africa, and Eswatini with funding from the Bristol Myers Squibb Foundation. This program was developed to improve lung cancer care by focusing on case identification, diagnostics, referral, treatment, and palliative care in coordination with local communities and each Ministry of Health.

In Kenya, this program collaborated with the Academic Model Providing Access to Health Care, a longstanding global health collaboration between Moi University, Moi Teaching and Referral Hospital (MTRH), and a consortium of North American academic health centers led by the Indiana University School of Medicine, which has over 10 years of designated oncology collaboration.^{23,24} This study took place at MTRH, a Kenya National Cancer Institute–designated comprehensive cancer center located in Eldoret, Kenya, which serves a mostly rural population of 24 million people. Currently, more than 150 patients receive cancer-directed treatment daily at MTRH from 10 oncology-trained providers. Before this program, there were no designated efforts for lung cancer prevention, diagnosis, or treatment in western Kenya.

Study Population

Patients with a pathologically confirmed diagnosis of NSCLC at MTRH from January 1, 2018, to December 31, 2022, and enrolled in this program were included for analysis. Patients were identified through a community-level case identification and referral system that was supported by this program (Fig 1). In this system, community health volunteers identified patients with symptoms of a lung condition,

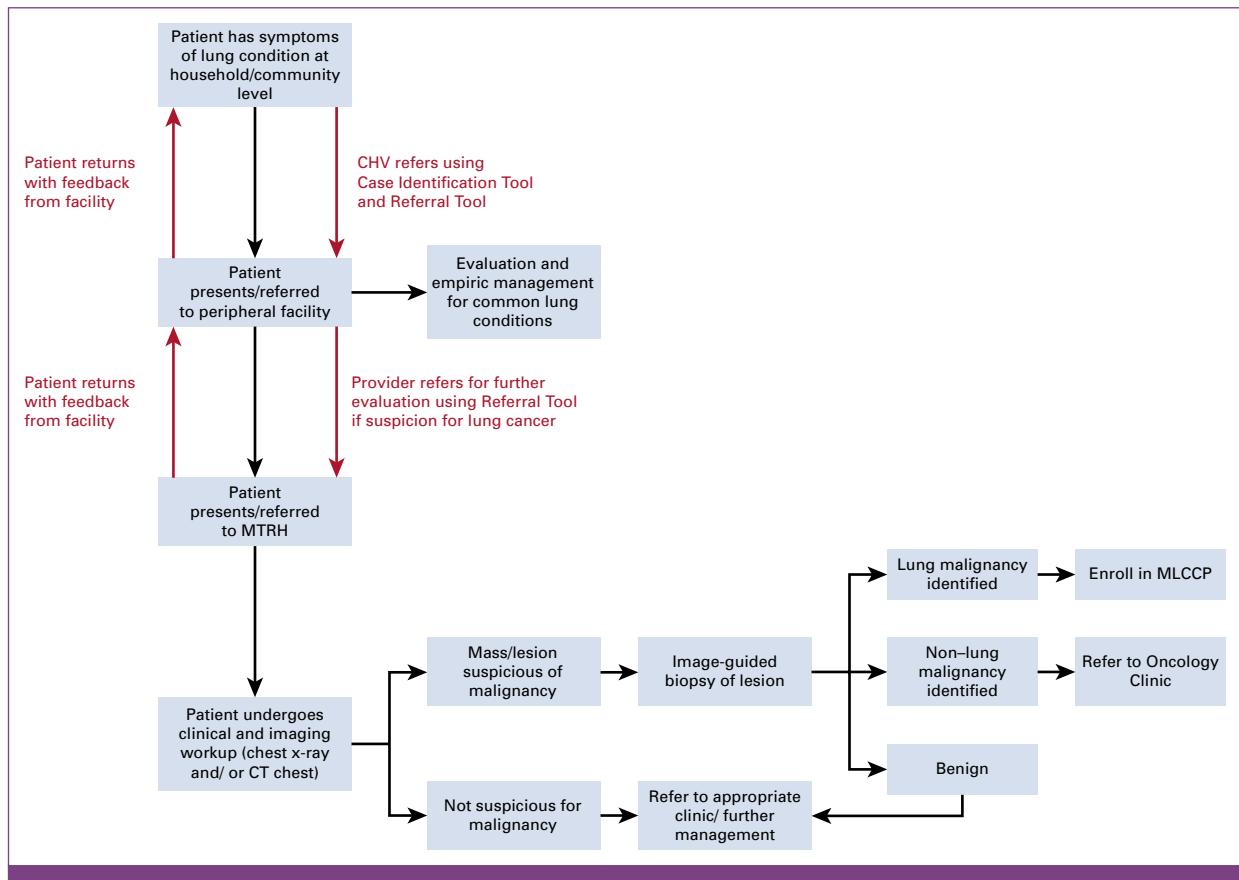


FIG 1. Referral cascade of patients with symptoms of a lung condition to support the identification of lung cancer cases from the community level to treatment site, MTRH in western Kenya, January 2018-December 2022. CHV, community health volunteer; CT, computed tomography; MLCCP, Multi-National Lung Cancer Control Program; MTRH, Moi Teaching and Referral Hospital.

namely, tuberculosis (TB), at the household level using a WHO case identification and referral tool. This tool was presented to the local health facility where those with high suspicion for lung cancer, including those patients whose symptoms did not respond to TB treatment or other empiric treatments for respiratory diseases, were referred to MTRH for a lung cancer evaluation using a Facility Referral Tool.

Study Procedures

Pathologic confirmation of NSCLC was conducted by one of three MTRH pathologists with additional studies such as immunohistochemistry (IHC) conducted at the discretion of the pathologist and treating oncologist. A diagnosis of squamous cell carcinoma (SCC) was made morphologically by the presence of squamous differentiation, keratinization, and prominent intercellular bridges. Markers of squamous differentiation, including p63 and p40, were typically reserved for poorly differentiated tumors. A diagnosis of adenocarcinoma was made morphologically with thyroid transcription factor-1 (TTF-1) used for differentiating NSCLC from other primary tumors. Patients were recommended to undergo staging using computed tomography of

the chest, abdomen, pelvis, and brain (or brain magnetic resonance imaging) in concordance with the seventh American Joint Committee on Cancer Tumor Nodal Metastasis staging system.²⁵ Available therapies during this study period included chemotherapy, radiotherapy, surgery, and palliative care referral and were selected by the treating individual provider which included a medical or clinical oncologist. Chemotherapy was administered in accordance with National Comprehensive Cancer Network Harmonized Guidelines for sub-Saharan Africa (SSA) for NSCLC as doublet chemotherapy with a platinum and taxane recommended as first-line.²⁶ Radiotherapy included any type of radiotherapy given to a primary or metastatic site. Targeted molecular therapies, immunotherapy, and chemotherapy regimens such as pemetrexed were infrequently available.

Data Collection and Analysis

We conducted a retrospective chart review of patients diagnosed with NSCLC at MTRH and enrolled in this program during the study period. Demographic characteristics and clinical data including Eastern Cooperative Oncology Group (ECOG) performance status (PS), pathology reports, and

TABLE 1. Baseline Characteristics of Patients Diagnosed With Non–Small Cell Lung Cancer at Moi Teaching and Referral Hospital in Western Kenya, January 2018-December 2022

Characteristic	Overall (N = 249)	Male (n = 125)	Female (n = 124)	P ^a
Age, years, median (IQR)	61 (52-70)	63 (53-70)	60 (51-69)	.295
Age categories, years, No. (%)				
<40	24 (9.6)	11 (8.8)	13 (10)	.857
40-49	27 (11)	11 (8.8)	16 (13)	
50-59	62 (25)	32 (26)	30 (24)	
60-69	72 (29)	37 (30)	35 (28)	
≥70	63 (25)	33 (26)	30 (24)	
Missing	1 (0.4)	1 (0.8)	0	
Enrolled in NHIF, No. (%)				.593
No	104 (42)	55 (44)	49 (40)	
Yes	133 (53)	63 (50)	70 (56)	
Missing	12 (4.8)	7 (5.6)	5 (4.0)	
Referral, No. (%)				.912
Self-referral	34 (14)	19 (15)	15 (12)	
Public health facility	116 (47)	56 (45)	60 (48)	
TB chest clinic	11 (4.4)	7 (5.6)	4 (3.2)	
Private clinic	42 (17)	21 (17)	21 (17)	
Inpatient referral	21 (8.4)	10 (8.0)	11 (8.9)	
Missing	25 (10)	12 (9.6)	13 (10)	
Highest education, No. (%)				.007
None	47 (19)	13 (10)	34 (27)	
Primary level	88 (35)	48 (38)	40 (32)	
Secondary level	50 (20)	24 (19)	26 (21)	
Tertiary level	37 (15)	23 (18)	14 (11)	
Missing	27 (11)	17 (14)	10 (8.1)	
Marital status, No. (%)				<.001
Single	9 (3.6)	4 (3.2)	5 (4.0)	
Married	177 (71)	103 (82)	74 (60)	
Separated/widowed/divorced	41 (16)	6 (4.8)	35 (28)	
Missing	22 (8.8)	12 (9.6)	10 (8.1)	
TB treatment, No. (%)				.177
No	108 (43)	48 (38)	60 (48)	
Yes	58 (23)	36 (29)	22 (18)	
Unknown	77 (31)	38 (30)	39 (31)	
Missing	6 (2.4)	3 (2.4)	3 (2.4)	
Smoker, No. (%)				<.001
Yes	71 (29)	59 (47)	12 (9.7)	
No	177 (71)	65 (52)	112 (90)	
Missing	1 (0.4)	1 (0.8)	0	
Passive (second hand) smoke, No. (%)				.006
Yes	23 (9.2)	5 (4.0)	18 (15)	
No	225 (90)	119 (95)	106 (85)	
Missing	1 (0.4)	1 (0.8)	0	
If smoker, median number of pack-years (IQR; n = 65)	10 (4-17)	10 (4-18)	8 (4-15)	.630
Family history of cancer, No. (%)				.732
No	208 (84)	104 (83)	104 (84)	
Yes	20 (8.0)	9 (7.2)	11 (8.9)	
Missing	21 (8.4)	12 (9.6)	9 (7.3)	

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TABLE 1. Baseline Characteristics of Patients Diagnosed With Non-Small Cell Lung Cancer at Moi Teaching and Referral Hospital in Western Kenya, January 2018-December 2022 (continued)

Characteristic	Overall (N = 249)	Male (n = 125)	Female (n = 124)	P ^a
BMI, median (IQR; n = 142)	20.9 (18.0-24.8)	20.0 (17.7-22.7)	21.6 (18.6-26.9)	.019
ECOG performance status, No. (%)				.324
1	106 (43)	60 (48)	46 (37)	
2	57 (23)	28 (22)	29 (23)	
3	26 (10)	9 (7.2)	17 (14)	
4	10 (4.0)	5 (4.0)	5 (4.0)	
Missing	50 (20)	23 (18)	27 (22)	
Comorbidities, No. (%)				
Current TB	38 (15)	24 (19)	14 (11)	.083
Hypertension	37 (15)	16 (13)	21 (17)	.359
Pneumonia	37 (15)	16 (13)	21 (17)	.359
HIV	16 (6.4)	7 (5.6)	9 (7.3)	.594
Diabetes	11 (4.4)	5 (4.0)	6 (4.8)	.747
Asthma	6 (2.4)	3 (2.4)	3 (2.4)	.999
Heart	4 (1.6)	2 (1.6)	2 (1.6)	.999
Stroke	1 (0.4)	0	1 (0.8)	.498
Kidney disease	1 (0.4)	0	1 (0.8)	.498

NOTE. Bold indicates statistical significance.

Abbreviations: ECOG, Eastern Cooperative Oncology Group; NHIF, National Health Insurance Fund; TB, tuberculosis.

^aWilcoxon sum-rank test; Pearson chi-square test; Fisher's Exact test.

cancer staging, along with the treatment received, were reviewed. Patients were followed until death, loss to follow-up (LTFU), or last censorship date of December 31, 2022. LTFU was defined as failure of the patient to present to clinic or be contacted by the care team for at least 90 days. Demographic, staging, and treatment characteristics were summarized for the cohort using descriptive statistics. Differences in patient characteristics on the basis of gender were calculated using Pearson's chi-square test and Fisher's exact test for categorical variables and Wilcoxon rank-sum test for continuous variables. Overall survival (OS) was calculated as the date of diagnosis until the date of death, LTFU, or last censorship. Kaplan-Meier methods were used to calculate OS and log-rank test to determine survival differences between groups. Hazard ratios and 95% CIs were estimated using the Cox proportional hazards regression model. Univariable and multivariable analyses (stepwise procedure) were used to assess prognostic factors associated with 1-year OS. All tests were two-sided and a significance level of $\alpha = .05$ determined statistical significance. Analyses were conducted using R version 4.2.2. This study was approved by the MTRH Institutional Research and Ethics Committee. Informed consent was not obtained given the retrospective nature of this study.

RESULTS

Patient Demographic and Clinical Characteristics

A total of 249 patients with a pathologic diagnosis of NSCLC were included for analysis (Table 1). Sixteen patients with

small cell lung cancer, who were cared for in this program, were excluded from this analysis. Patients with NSCLC were identified and enrolled consistently over the study period from 2018 to 2022 which notably coincided with the COVID-19 pandemic (Fig 2). The sex distribution was nearly proportional with 125 males (50.2%) and 124 females (49.8%) enrolled. The median age at diagnosis was 61 years and did not differ by sex. Of note, 51 patients (20.5%) were under age 50 years. Most patients (53%) were registered with the National Health Insurance Fund (NHIF), Kenya's public health insurance plan. Compared with females with NSCLC, males were more likely to have higher education ($P = .07$), lower BMI ($P = .019$), and be married ($P \leq .001$). Additionally, men were more likely to report being active smokers ($P = .001$), whereas women were more likely to report exposure to passive or secondhand smokers ($P = .006$). Among smokers, the median pack-years smoked was only 10 (IQR, 4-17). Fifty-eight patients (23%) reported having undergone treatment for TB in the past. A significant proportion of patients were debilitated at presentation with 43% having an ECOG PS of 1 and 37% with an ECOG of 2 or greater.

Adenocarcinoma was the predominant NSCLC pathologic subtype (n = 187, 75%; Table 2) with epidermoid/SCC reported in 62 patients (25%). A total of 43 (17.3%) patients underwent any type of IHC testing including 13 patients for cytokeratin (CK) 7, four patients for CK20, and 35 patients for TTF-1. Of those with documented staging, most presented with stage IV disease (195, 78%) and all had at least stage III disease (Table 2). The majority of the patients received both

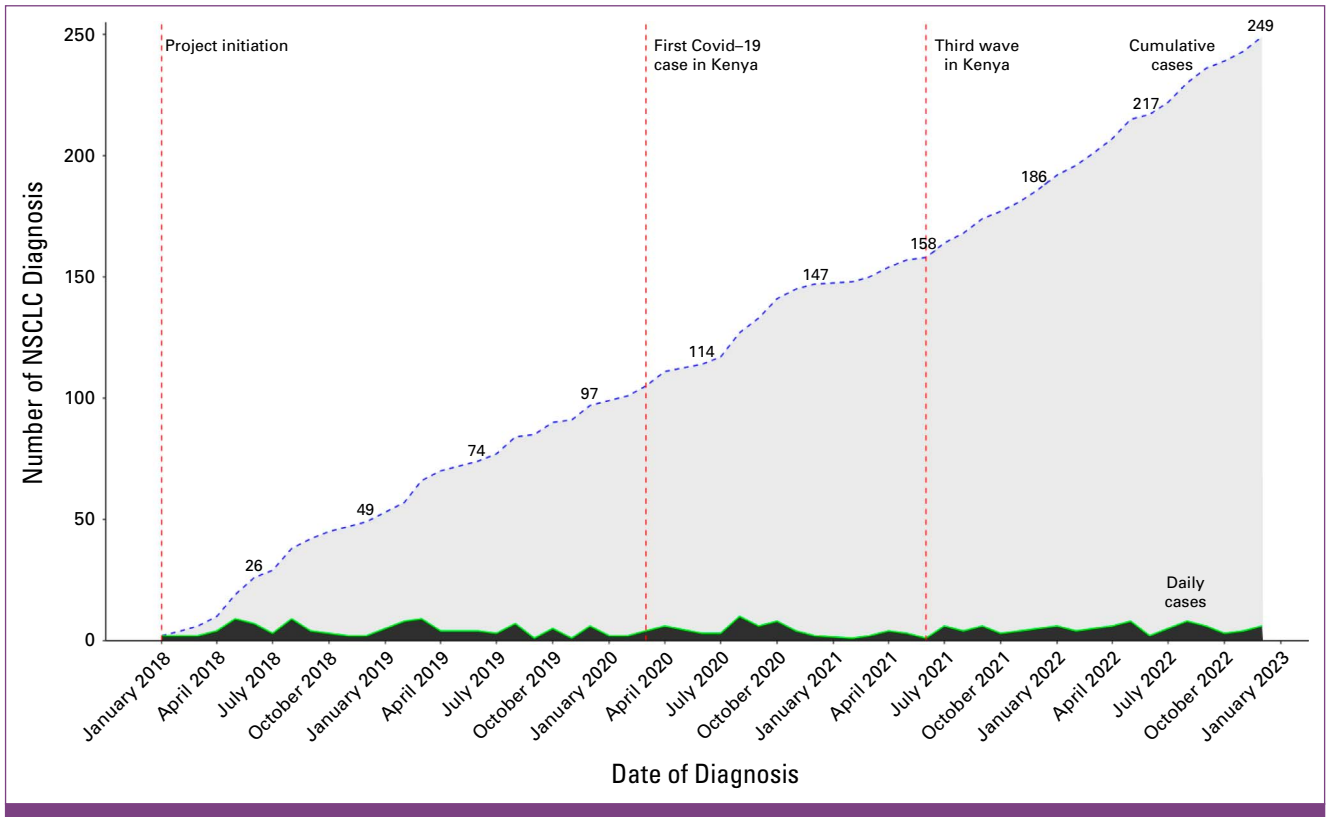


FIG 2. Daily and cumulative enrollment of patients diagnosed with NSCLC at Moi Teaching and Referral Hospital in western Kenya, January 2018-December 2022, in the context of the COVID-19 pandemic and major COVID-related events in Kenya. NSCLC, non-small cell lung cancer.

chemotherapy and radiation ($n = 176$, 71%), followed by chemotherapy alone ($n = 65$, 26%) and radiotherapy alone ($n = 5$, 2%). Only two patients (0.8%) were referred to palliative care at the time of diagnosis.

OS

With a maximum follow-up of 5 years, 207 (83.1%) of 249 enrolled patients died during the study period. The median OS for the entire cohort was 3.7 months (95% CI, 2.7 to 5.4 months; Fig 3A). Additionally, we calculated the probability of survival beyond specific time intervals which were estimated as follows: 53% (95% CI, 47 to 60) beyond 3 months, 41% (95% CI, 35 to 48) beyond 6 months, 24% (95% CI, 19 to 31) beyond 1 year, and 13% (95% CI, 8.6 to 18) beyond 2 years.

As 177 (71%) of the 249 patients had died by the 1-year mark, we elected to conduct 1-year OS (Fig 3A). Advanced clinical stage ($P < .001$; Fig 3E) and higher ECOG PS ($P < .001$; Fig 3F) were associated with poor 1-year OS. The median OS for patients presenting with stage III disease was 11 months compared with 4.9 months and 0.4 months for patients with stage IV and unstaged disease, respectively (Fig 3E). The median OS for ECOG PS of 1 was 8.8 months compared with 2.2 months, 1.5 months, and 0.9 months for ECOG PS of 2, 3, and 4, respectively (Fig 3F). One-year OS did not vary by NHIF status (Fig 3B), smoking status (Fig 3C), pathologic

subtype of NSCLC (Fig 3D), gender (Appendix Fig A1A), stratification by age and smoking status (Appendix Fig A1B), TB treatment received (Appendix Fig A1C), type of oncology treatment received (Appendix Fig A1D), or advanced age (>60) alone (Appendix Fig A1E). Additionally, in multivariable analysis, only ECOG PS and clinical stage were observed as independent predictive factors for 1-year OS (Table 3).

DISCUSSION

Here, we present the first depiction of patients with NSCLC from a single institution in western Kenya. Importantly, identification of patients with NSCLC was facilitated by MLCCP which leveraged an existing community-level initiative around case identification of lung conditions, namely, TB. Given concern for lower-than-expected incidence of lung cancer in Kenya, case identification should be a significant priority in both understanding the lung cancer landscape in the country and facilitating early diagnosis to improve outcomes. The MLCCP consistently identified patients with NSCLC over the study period, even through the COVID-19 pandemic, and created a foundational referral pathway for patients with lung cancer in western Kenya.

Our study revealed a cohort of patients who presented with advanced-stage NSCLC, poor PS, and low 1-year survival of 24% as shown in Figure 3A. Survival in this cohort is notably

TABLE 2. Pathologic Characteristics, Staging, and Treatment of Patients Diagnosed With Non-Small Lung Cancer at Moi Teaching and Referral Hospital in Western Kenya, January 2018-December 2022

Characteristic	Overall (N = 249), No. (%)	Male (n = 125), No. (%)	Female (n = 124), No. (%)	P ^a
Non-small cell subtype				.256
Adenocarcinoma	187 (75)	90 (72)	97 (78)	
Epidermoid carcinoma/squamous cell carcinoma	62 (25)	35 (28)	27 (22)	
Metastatic site				
Pleura	94 (38)	49 (39)	45 (36)	.636
Liver	64 (26)	26 (21)	38 (31)	.075
Lung	35 (14)	15 (12)	20 (16)	.349
Bones	31 (12)	18 (14)	13 (10)	.349
Brain	20 (8.0)	12 (9.6)	8 (6.5)	.361
Spine	14 (5.6)	5 (4.0)	9 (7.3)	.264
Clinical stage				.766
III	14 (5.6)	6 (4.8)	8 (6.5)	
IV	195 (78)	100 (80)	95 (77)	
Not staged	40 (16)	19 (15)	21 (17)	
Treatment received				.973
Chemotherapy and radiotherapy	176 (71)	89 (71)	87 (70)	
Chemotherapy alone	65 (26)	33 (26)	32 (26)	
Radiotherapy alone	5 (2.0)	2 (1.6)	3 (2.4)	
Palliative care referral	2 (0.8)	1 (0.8)	1 (0.8)	
Missing	1 (0.4)	0	1 (0.8)	
Death	207 (83)	109 (87)	98 (79)	.085

^aPearson's chi-square test; Fisher's exact test.

lower than the few studies published on lung cancer in the region, including 41% and 75.5% 1-year OS found in Ugandan and Kenyan studies, respectively.^{27,28} Predictors of survival in our cohort were limited to PS and disease stage at diagnosis, which in the absence of significant comorbidities likely reflects late-stage presentations. Late-stage presentations of cancer are unfortunately common across cancer types in Kenya and SSA and have been attributed to the complex interplay between patient and health system factors including variable health-seeking behaviors, far distances to care, lengthy diagnostic and referral processes, variable quality of treatment, and availability of patient support.²⁹⁻³³ These factors are likely even more prominent among programs like ours that serve a rural population and may explain worse outcomes than studies from major cancer referral centers in urban environments in the region.^{27,28,33}

Although we implemented the first designated case finding effort in western Kenya as an initial step toward a lung cancer diagnosis and treatment system, a more comprehensive and multitargeted approach is needed to combat the advanced presentations seen in our cohort. From this program, we identified key gaps in our identification and referral process that warrant further resources to improve lung cancer outcomes. First, prioritizing increased community awareness of lung cancer is needed to recognize symptoms earlier. Public health campaigns should be undertaken in rural

communities, deploy trusted community health workers, be deliberate and clear in their messaging across multiple platforms, and use previously successful communication strategies.^{34,35} Second, directed education for health care providers could raise the level of clinical suspicion for lung cancer and hasten diagnoses. Recently surveyed health providers in South Africa recommended prioritizing the following educational topics to improve lung cancer outcomes including general lung cancer awareness, timely access to evidence-based care, and patient-centered care initiatives including psychosocial support.³⁶ Using virtual platforms such as Project Extension for Community Healthcare Outcomes could facilitate lung cancer education among diverse groups of health providers and may lead to an increased number of lung cancer diagnoses as has been shown in other cancer groups in western Kenya.^{37,38} Third, ensuring that case identification and referral tools are paired with early imaging and linkage to specialized oncology facilities is essential for early diagnosis.^{39,40} Innovative strategies such as deploying artificial intelligence (AI) to aid in review of lung images could potentially hasten lung cancer diagnoses in the face of a limited health care workforce although specific implementation strategies warrant further investigation.⁴¹ Additionally, early virtual consultation or patient navigation programs to specialized oncology centers have been underused and may aid in facilitating timely diagnosis and treatment.^{42,43}

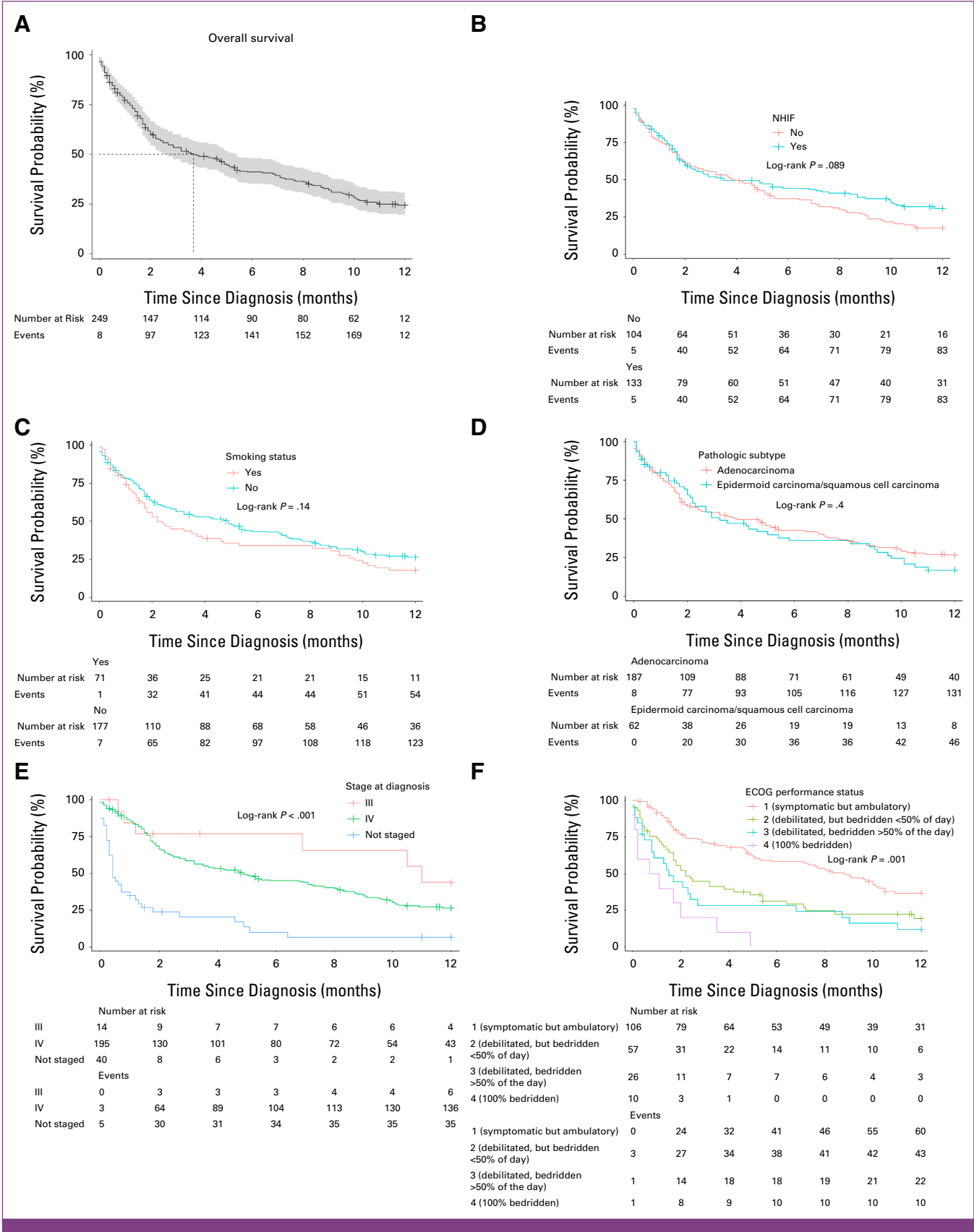


FIG 3. OS of patients diagnosed with non-small lung cancer at Moi Teaching and Referral Hospital in western Kenya, January 2018-December 2022, by (A) OS, (B) NHIF status, (C) smoking status, (D) pathologic subtype, (E) stage at diagnosis, and (F) ECOG performance status. ECOG, Eastern Cooperative Oncology Group; NHIF, National Health Insurance Fund; OS, overall survival.

TABLE 3. Prognostic Factors Included in the Cox Proportional Hazards Model for Prediction of 1-Year Survival of Patients Diagnosed With Non-Small Cell Lung Cancer at Moi Teaching and Referral Hospital in Western Kenya, January 2018-December 2022

Characteristic	Unadjusted HR (95% CI)	<i>P</i> ^a	Adjusted HR (95% CI)	<i>P</i> ^b
NHIF				
No	Ref		Ref	
Yes	0.94 (0.69 to 1.27)	.694	0.92 (0.64 to 1.34)	.679
ECOG performance status				
1 (symptomatic but ambulatory)	Ref		Ref	
2 (debilitated, but bedridden <50% of day)	1.34 (0.90 to 2.00)	.151	1.39 (0.91 to 2.12)	.131
3 (debilitated, bedridden >50% of the day)	2.01 (1.23 to 3.28)	.005	2.41 (1.42 to 4.11)	.001
4 (100% bedridden)	3.41 (1.72 to 6.74)	<.001	2.88 (1.39 to 5.98)	.005
Stage				
III	Ref		Ref	
IV	1.69 (0.74 to 3.84)	.211	2.11 (0.77 to 5.78)	.148
Not staged	4.32 (1.80 to 10.3)	.001	6.40 (2.21 to 18.5)	<.001
TB treatment				
No	Ref		Ref	
Unknown	1.12 (0.79 to 1.58)	.531	0.78 (0.50 to 1.21)	.261
Yes	1.05 (0.72 to 1.53)	.814	0.97 (0.61 to 1.53)	.892
Smoker				
No	Ref		Ref	
Yes	1.21 (0.88 to 1.67)	.250	1.29 (0.85 to 1.96)	.232

NOTE. Bold indicates statistical significance.

Abbreviations: ECOG, Eastern Cooperative Oncology Group; HR, hazard ratio; NHIF, National Health Insurance Fund; Ref, reference value; TB, tuberculosis.

^aUnadjusted *P* value.

^bAdjusted *P* value.

Our program was also tasked with the challenge of diagnosing lung cancer in a setting where TB is endemic.⁴⁴ The relationship between TB and lung cancer is complex and likely interdependent with studies showing that previous TB infection is associated with an increased risk of lung cancer through the development of chronic inflammation.^{45,46} Additionally, because of overlapping symptoms, lung cancer is often misdiagnosed as TB, which can contribute to significant delays and poor outcomes following lengthy anti-TB regimens.⁴⁷ In our cohort, 23% of patients received previous TB treatment; however, 31% of patients did not have information on previous TB treatment, limiting our interpretation of these findings. Our lung cancer referral pathway was integrated into an existing infrastructure for TB, and still further strategies to differentiate the two diagnoses early are needed and may be an important opportunity to apply AI for assisted imaging diagnosis as has been piloted in a similar setting.⁴⁸

Our outcomes are contrasted with patients in the United States who continue to experience increasing lung cancer survival with 2-year OS rates reaching 43%–54% as of 2018.⁴⁹ This has largely been attributed to advances in treatment such as molecular therapies targeting key oncogenic mutations and immune checkpoint inhibitors as well as improvements in staging.^{50,51} The advent of molecular therapies has particularly revolutionized NSCLC treatment in

HIC in which patients with advanced lung cancer who harbor an *ALK* mutation can now live up to 7 years with sequential treatment using *ALK* inhibitors.⁵² This differs from our setting and other LMICs where molecular diagnostics and therapies are largely unavailable except at high patient cost in private sectors.^{27,28,53,54} Understanding the molecular landscape of NSCLC through diagnostic testing can help to inform health systems with limited resources as to how molecular therapies may be prioritized. Resource adapted models for using less costly DNA allele-specific testing with polymerase chain reaction, fluorescence in situ testing, and IHC as well as noninvasive liquid biopsies for common oncogenic mutations are yet to be studied in LMICs like Kenya and could potentially improve access to molecular therapies.⁵⁵

Finally, despite having limited survival, our patients received considerable amounts of treatment (71% undergoing both chemotherapy and radiotherapy) with only two patients referred to palliative care at diagnosis. This is likely explained by the frequent receipt of palliative radiation to primary or metastatic sites for hemostasis or pain. However, this also represents a missed opportunity to incorporate palliative care which has been shown to not only minimize the use of burdensome treatment at the end of life and improve quality of life but also extend survival in patients with lung cancer.⁵⁶

We recognize that providing a real-world depiction of a lung cancer program comes with several limitations. Patients in this cohort classified as unstaged were likely too moribund to undergo staging, which explains their dismal outcomes. It is also likely that PS was overestimated, either by providers or by patients, on the basis of this cohort's short median OS. Lack of data on symptom duration, time to diagnosis, and time to treatment hampers our ability to inform interventions along the lung cancer care continuum. Gaining a deeper understanding of patient- and system-level delays using implementation science and qualitative methods is essential to informing these interventions.

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In conclusion, we present the first cohort of patients with NSCLC from a predominantly rural population in western Kenya where advanced-stage disease and poor survival predominate. Despite a designated lung cancer program with a focus on case finding, late diagnoses highlight a need for locally relevant and multitargeted interventions among communities and providers which can lead to early detection and prompt treatment. Additionally, improving access to innovative diagnostics and proven treatments including molecular therapies and palliative care will be essential to improving lung cancer outcomes in Kenya.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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APPENDIX

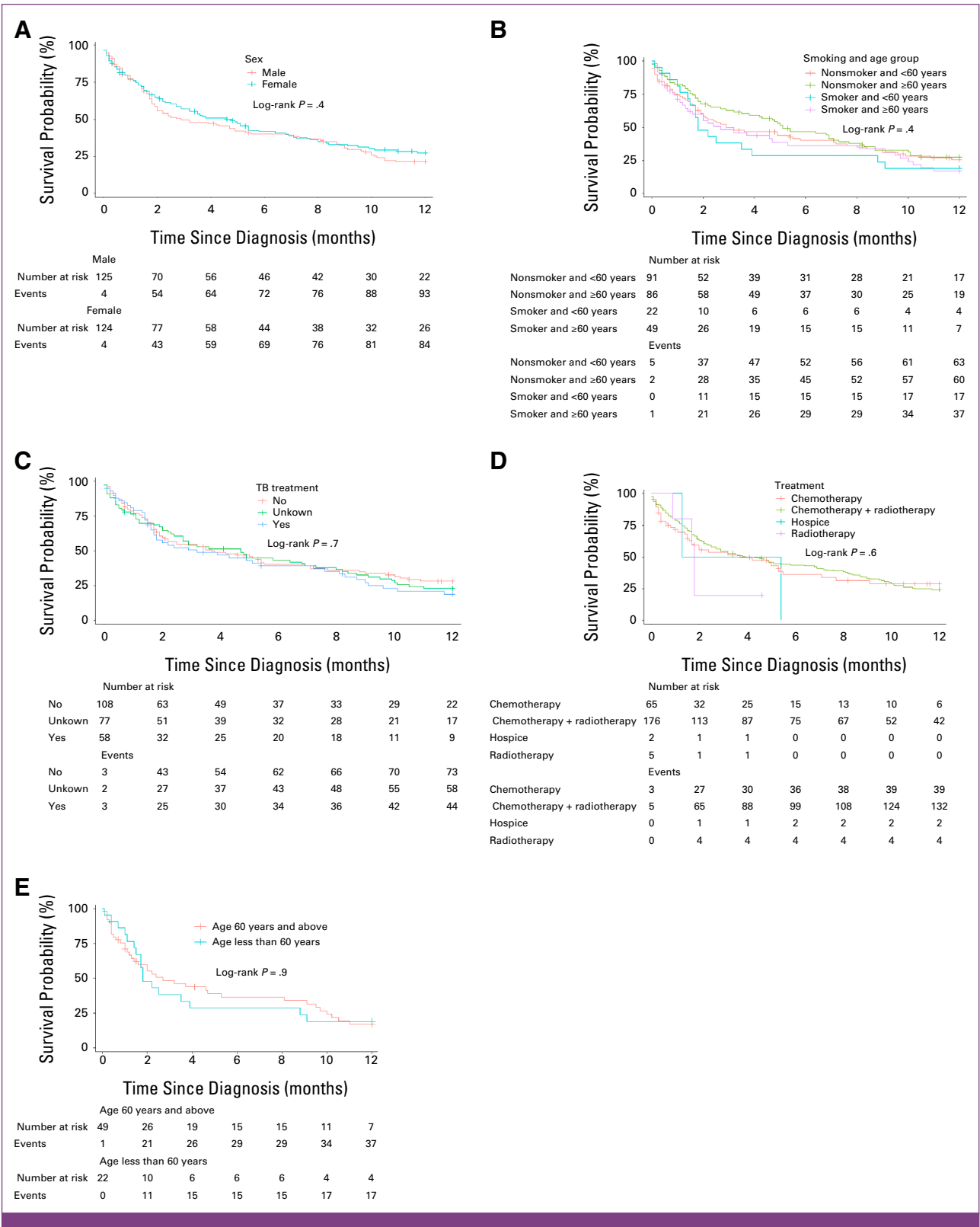


FIG A1. Overall survival of patients diagnosed with non-small cell lung cancer at Moi Teaching and Referral Hospital in western Kenya, January 2018-December 2022, by (A) sex, (B) smoking and age group, (C) TB treatment received, (D) oncology treatment received, and (E) advanced age. TB tuberculosis.