Cost and effectiveness of lung cancer screening in Poland: A 15-year projection

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Abstract

Lung cancer is the leading cause of cancer death among men and women in Poland, with about 21,000 deaths annually. Lung cancer screening (LCS) of high-risk populations has been demonstrated to save lives by shifting the stage of diagnosis to earlier stages where there is a high cure rate. LCS was recommended in the United States starting in 2013, and in 2022 the Council of the European Union encouraged EU Member States to implement LCS. However, little analysis has been published on the potential impacts of LCS on the Polish population.

We conducted a 15-year projection of the high-risk Polish population associated with smoking history using the framework of a previously published model. Under conditions of full compliance to screening and established outcomes of LCS, we estimate that over the 15-year period over a quarter of million life-years would be saved at an annual expense of on average PLN 4.9 billion (approximately EUR 1.1 billion). In the long run the screening program is estimated to bring an average 3.74 extra life-years per cancer case diagnosed.

While these results assume ideal compliance, the potential benefits of LCS in Poland are significant. Real-world lung cancer screening programs have been shown to yield substantial improvements in early detection rates and treatment outcomes.

Introduction

Lung cancer (LC) is the leading cause of cancer death worldwide with around 2 million incident cases and 1.8 million deaths (2020),[1] and, in 2021, there were about 20,600 cases and 20,800 deaths in Poland.[2] Early-stage lung cancers are highly curable, but most lung cancers are detected symptomatically at late stages and most patients die within a year or two of diagnosis. Lung cancer screening (LCS) programs for high-risk patients using low-dose computed tomography (LDCT) have demonstrated dramatically improved survival, because LCS reliably shifts the stage of diagnosed LC to earlier stages.

In late 2022 the Council of the European Union proposed new recommendations on cancer screening[3] that includes LCS. They encourage EU Member States to implement population-based, quality-assured screening programs with a stepwise approach: first assessing benefits and cost-effectiveness, including the potential impact on savings for health and long-term care systems, covering the target population and following evidence-based and up-to-date European guidelines.

1. Saving Lives From Lung Cancer (May 2024). Retrieved 23 October 2024 from https://www.lungcancerlivessaved.com/.
2. Krajowy Rejest Nowotworów, Cancer in Poland in 2021. See https://onkologia.org.pl/sites/default/files/publications/2024-02/0_krn-2023-book-2024-02-13-pass.pdf. In 2020 19,100 cases and 22,200 deaths. See https://onkologia.org.pl/pl/raporty.
3. Council of the European Union (29 November 2022). Council Recommendation on Strengthening Prevention Through Early Detection: A New EU Approach on Cancer Screening Replacing Council: Recommendation 2003/878/EC. Retrieved 23 October 2024 from https://data.consilium.europa.eu/doc/document/ST-14770-2022-INIT/en/pdf.

While LCS was officially recommended in the US starting in 2013,[4] Croatia became the first European country to implement LCS in October 2020. Croatia's program targets people aged 50 to 75 with a smoking history of at least 30 pack-years,[5] who currently smoke or have stopped smoking within the past 15 years.[6] National pilots have also been carried out in Poland[7] and other European countries. In Poland, in 2024, the National Oncology Strategy for the 2020-2030 period was amended to include an intention to introduce a publicly funded screening program for high-risk groups to detect lung cancer starting from 2025.[8]

This article aims to contribute to the discussion of the cost and effectiveness of LCS in Poland by providing a forecast of screening and follow-up costs and mortality gains due to LCS. We consider several factors included in the Council recommendations such as epidemiology and incurred expenses. Other factors such as healthcare organizational readiness, service delivery and obtaining sufficiently high participation are not included in our analysis.

Methods

The analysis is based on a Markov model similar to the work of F. Hofer et al.,[9] which was used for Germany. Our model was developed in R. We modelled the natural history of disease for the Polish target population of people aged 50 to 75 with a smoking history of 20 pack-years, including people who quit smoking. The natural history component of the lung cancer screening model simulates an individual's progression of lung cancer over time in the absence of screening. The model uses a discrete-time Markov chain with a state for individuals with no lung cancer and various stages representing different stages of lung cancer (I, II, IIIA, IIIB, IV). The model assumes a cycle length of three months. Disease progression probabilities are calibrated to align with observed data, encompassing age-dependent mortality rates and available information on lung cancer stage progression and survival. This component allows us to understand the natural course of the disease in the absence of screening.

To estimate the impact of screening, screening processes and results are applied to individual trajectories. We assumed that every eligible person from the target group who meets age and smoking history criteria and has no prior diagnosis of lung cancer (including through LCS), gets screened once a year. We also applied established probabilities for clinical follow-up, including, for some individuals with important findings, a repeat of LCS before the next annual screen. Each individual has a trajectory that includes the potential date of lung cancer diagnosis and stage at diagnosis given the presence or absence (natural history) of the screening program.

Model

At the start of the simulation, time T0, we select 100,000 eligible individuals (see the *Target Group* section below). As each year passes in the simulation (every four three-month cycles), a new cohort of screening-eligible individuals aged 50, sampled from the forecast Polish population, enters the program. The size of the new entry cohorts considers population demographics, adjusted estimates for the smoking population (both current and former smokers) and mortality rates. A fixed proportion of males (55.3%)[10] is assumed for all new cohorts when they enter the program. No provision is made for new entrants older than age 50 (e.g., people who qualify for screening by attaining a 20-year pack-year history at age 55).

4. US Preventive Services Task Force (9 March 2021). Lung Cancer: Screening. Retrieved 23 October 2024 from https://www.uspreventiveservicestaskforce.org/uspstf/recommendation/lung-cancer-screening.

5. Pack-years is a clinical metric used to quantify cumulative exposure to smoking. It is calculated by multiplying the number of packs of cigarettes smoked per day by the number of years the person has smoked. Thirty pack-years encompasses cases of one pack of cigarettes smoked per day for 30 years, two packs per day for 15 years, three packs per day for 10 years, etc.

6. Lung Cancer Policy Network (20 December 2023). Lung Cancer Screening in Croatia: Leading the Way for Earlier Detection in Europe. Retrieved 23 October 2024 from https://www.lungcancerpolicynetwork.com/lung-cancer-screening-in-croatia/.

7. Van Meerbeeck, J.P., O'Dowd, E., Ward, B., Van Schil, P. & Snoeckx, A. (9 May 2022). Lung Cancer Screening: New Perspective and Challenges in Europe. Cancers (Basel);14(9):2343. doi: 10.3390/cancers14092343. PMID: 35565472; PMCID: PMC9099920.

8. Resolution of the Council of Ministers on the Adoption of National Oncology Strategy for 2020-2030. Retrieved 23 October 2024 from https://isap.sejm.gov.pl/isap.nsf/download.xsp/WMP20240000204/O/M20240204.pdf.

9. Hofer, Kauczor & Stargardt (October 2018). Cost-Utility Analysis of a Potential Lung Cancer Screening Program for a High-Risk Population in Germany: A Modelling Approach. Lung Cancer;124:189-198. doi: 10.1016/j.lungcan.2018.07.036. Epub 2018 Jul 24. PMID: 30268459.

10. The proportion was based on the share of males in the modelled population of 50- to 74-year-olds. Source: Population by Sex and Age in 2022, Statistics Poland. See https://stat.gov.pl/en/topics/population/population/population-size-and-structure-and-vital-statistics-in-poland-by-territorial-division-as-of-31-december,3,33.html.

We illustrate the methodology with two sample trajectories. The simulation generates *life trajectories*, which describe the progression of screening-eligible people from T0 and their development of lung cancer (if any) until eventual clinical diagnosis or death. All individuals are observed every three months (four times a year). In the screening module, we start with the previously generated trajectories and apply an annual low-dose computer tomography (CT) screening. Using screening effectiveness parameters (see the *Screening Parameters* section below), including sensitivity of cancer detection by lung cancer stage, one of the three outcomes is assigned: a positive result (indicating a lung cancer diagnosis), a negative result (no diagnosis, in such case the next screening cycle will be in 12 months), or a potential important finding requiring follow-up, where a screening is repeated in three months (early recall).

FIGURE 1: CASE 1A. *NATURAL HISTORY.* AN INDIVIDUAL WHO DEVELOPED LUNG CANCER AND WAS DIAGNOSED THROUGH STANDARD CLINICAL CARE WHEN THEY BECAME SYMPTOMATIC

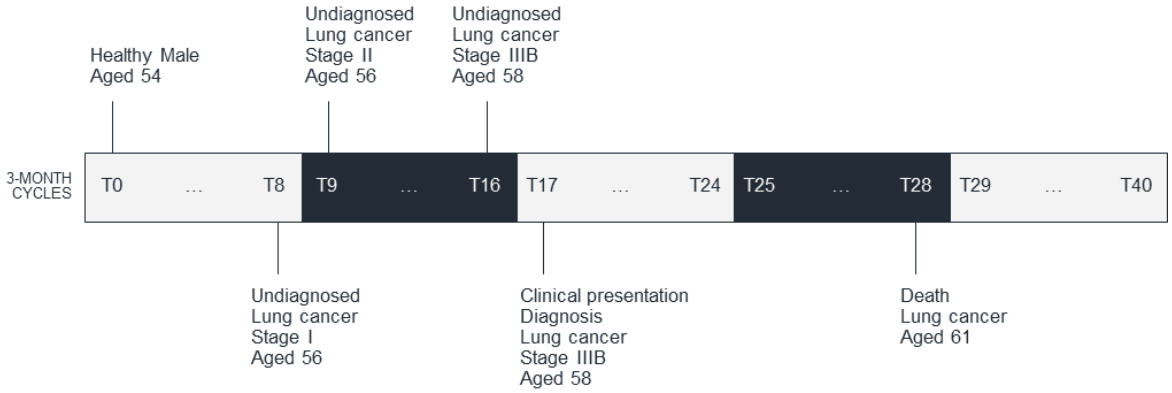
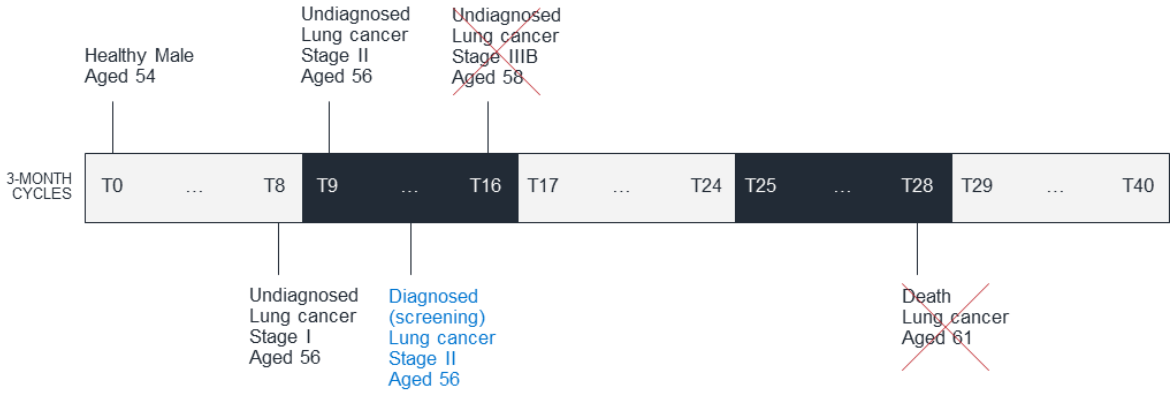


FIGURE 2: CASE 1B. *SCREENING.* AN INDIVIDUAL WHO DEVELOPED LUNG CANCER AND GOT DIAGNOSED EARLIER, THROUGH THE LUNG CANCER SCREENING PROGRAM



In Case 1a a man developed lung cancer and got diagnosed through standard examination when he became symptomatic. For Case 1b the screening diagnosis comes earlier both in terms of time and lung cancer stage. It's important to note that some individuals undergoing annual screenings could also be diagnosed symptomatically between screening cycles. These cases are called "interval cancers." They are modelled as cancer diagnoses occurring between screening events.

The model accommodates the rare cases of overdiagnosis. These are cases where LCS detects lung tumors that would likely not have been noticed without screening. Overdiagnosis might occur under two scenarios: 1) cases of persistently nonprogressive cancer or non-cancers that resemble cancer,[11] or 2) cases of cancer that grow so slowly

11. Folkman, J. & Kalluri, R. (26 February 2004). Cancer Without Disease. Nature 427, 787. Retrieved 23 October 2024 from https://doi.org/10.1038/427787a.

that the patient would be expected to die of other causes under normal mortality assumptions before it becomes symptomatic. Long-term studies show that overdiagnosis through LCS is close to zero.[12,13]

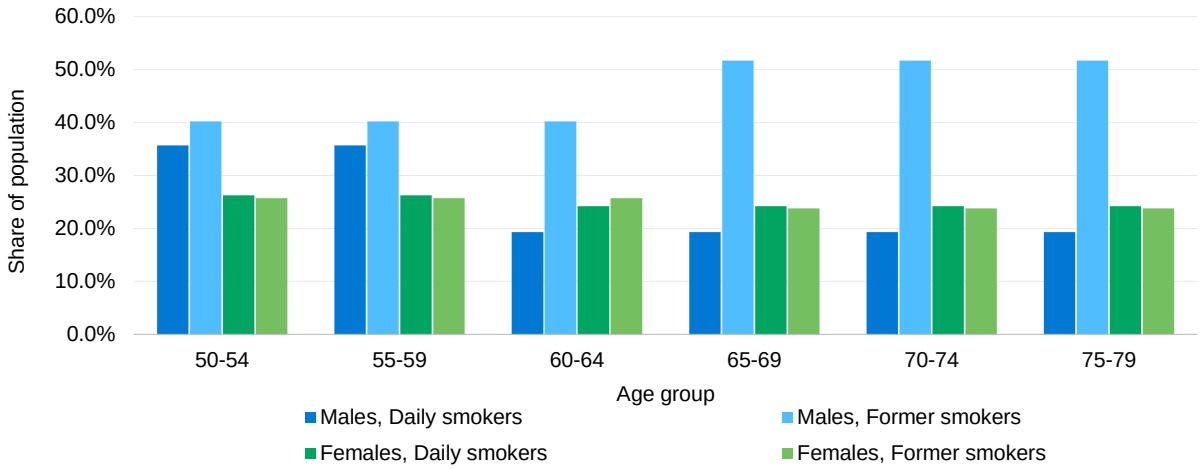
In keeping with actuarial practice, we did not discount the count of future lives for their present value. We neither inflated nor deflated future prices in our model and did not discount future spending, which amounts to assuming that inflation and discount rates will be the same.

Key parameters and assumptions evaluation

TARGET GROUP

People aged 50 to 75 with a smoking history of 20 pack-years. The size and structure of the Polish population was based on 2022 data.[14] Assumptions on the smoking population were based on literature. Current and former smokers' proportion of the target group varies from 37% to 71% with age and sex.[15]

FIGURE 3: ESTIMATES OF CURRENT AND FORMER SMOKERS IN POLISH POPULATION IN 2022



LIFE EXPECTANCY

Life expectancy was based on 2022 life tables.[16] Probability of death was adjusted to the three-month cycle. Mortality rates for individuals in the target population (aged 50+) in the natural history component were adjusted for heavy smokers with a mortality load factor of 1.9,[17] resulting in a reduced natural history life expectancy among the target population of an average of 4.9 years for males and 4.7 years for females aged 50 to 75 relative to nonsmokers.

12. Paci, E., Puliti, D., Lopes Pegna, A., Carrozzi, L., Picozzi, G., Falaschi, F., Pistelli, F., Aquilini, F., Ocello, C., Zappa, M., Carozzi, F.M., & Mascalchi, M.; the ITALUNG Working Group (September 2017). Mortality, Survival and Incidence Rates in the ITALUNG Randomised Lung Cancer Screening Trial. Thorax;72(9):825-831. doi: 10.1136/thoraxjnl-2016-209825. Epub 2017 Apr 4. PMID: 28377492.

13. Yankelevitz, D.F., Henschke, C.I. (February 2021). Overdiagnosis in Lung Cancer Screening. Transl Lung Cancer Res.;10(2):1136-1140. doi: 10.21037/tlcr-20-736. PMID: 33718051; PMCID: PMC7947395.

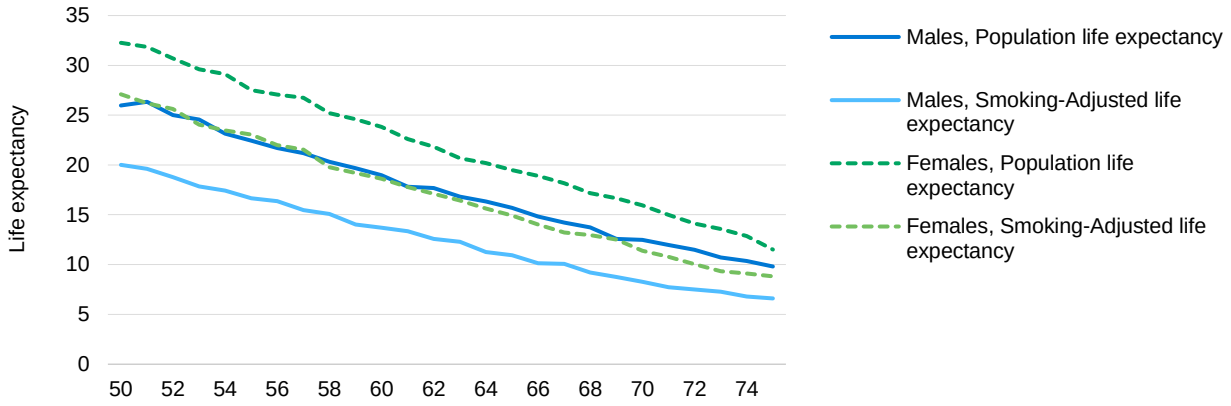
14. Statistics Poland (28 April 2023). Population. Size and Structure and Vital Statistics in Poland by Territorial Division. As of 31 December. Retrieved 23 October 2024 from https://stat.gov.pl/en/topics/population/population/population-size-and-structure-and-vital-statistics-in-poland-by-territorial-division-as-of-31-december,3,33.html.

15. Jankowski, M., Ostrowska, A., Sierpiński, R., Skowron, A., Sytnik-Czetwertyński, J., Giermaziak, W., Gujski, M., Wierzba, W. & Pinkas, J. (18 April 2022). The Prevalence of Tobacco, Heated Tobacco and E-Cigarette Use in Poland: A 2022 Web-Based Cross-Sectional Survey. Int J Environ Res Public Health;19(8):4904. doi: 10.3390/ijerph19084904. PMID: 35457771; PMCID: PMC9031359.

16. Statistics Poland. Life Expectancy in Poland – Historical Tables. Retrieved 23 October 2024 from https://stat.gov.pl/en/topics/population/life-expectancy/life-expectancy-in-poland-historical-tables,1,3.html.

17. The 1.9 parameter is a result of model calibration to an assumed average of five-year decrease in overall life expectancy of smoking population. See https://ncez.pzh.gov.pl/abc-zywienia/rzucasz-palenie-sprawdzmy-dlaczego-warto-zadbac-o-diete/.

FIGURE 4: SMOKING-ADJUSTED LIFE EXPECTANCY



LUNG CANCER INCIDENCE RATES

Incidence rates of lung cancer were based on data from the Polish National Cancer Registry (KRN2020),[18] which also provides lung cancer death details (the tables in Figures 5 and 6). The registry provides the number of lung cancer cases, incidence rates and related information regarding cancer diagnoses within population. Age-group and sex-specific rates have been adjusted to account for the impact of lung cancer incidence rates attributable to smoking. We allocated 93% of the Polish lung cancers by age and sex to the target population.[19] These adjustments are made by considering both the estimated smoking population, which includes both current and former smokers, and the population-attributable fraction of lung cancers due to smoking.

FIGURE 5: TOTAL LUNG CANCER CASES IN POLAND

Age group	2020				2021			
	Males	Females	Total	% Total	Males	Females	Total	% Total
0-39	35	27	62	0%	49	36	85	0%
40-44	59	50	109	1%	55	52	107	1%
45-49	140	84	224	1%	147	93	240	1%
50-54	374	243	617	3%	359	227	586	3%
55-59	1,012	575	1,587	8%	966	511	1,477	7%
60-64	2,120	1,277	3,397	18%	2,093	1,353	3,446	17%
65-69	2,846	1,896	4,742	25%	3,058	2,056	5,114	25%
70-74	2,621	1,680	4,301	23%	2,825	2,077	4,902	24%
75-79	1,322	834	2,156	11%	1,488	987	2,475	12%
80-84	798	459	1,257	7%	858	563	1,421	7%
85+	386	272	658	3%	434	285	719	3%
TOTAL	**11,713**	**7,397**	**19,110**	**100%**	**12,332**	**8,240**	**20,572**	**100%**

18. Krajowy Rejestr Nowotworow. Reports. Retrieved 23 October 2024 from https://onkologia.org.pl/pl/raporty.

19. Mańczuk, M., Sulkowska, U., Łobaszewski, J., Koczkodaj, P., Przepiórka, I., Cedzyńska, M., Przewoźniak, K. & Didkowska, J. (2017). Time Trends in Tobacco-Attributable Cancer Mortality in Poland – Direct Estimation Method, Biuletyn Polskiego Towarzystwa Onkologicznego Nowotwory, Tom 2, Nr 4.

FIGURE 6: TOTAL LUNG CANCER DEATHS IN POLAND

Age group	2020				2021			
	Males	Females	Total	% Total	Males	Females	Total	% Total
0-39	18	16	34	0%	21	13	34	0%
40-44	56	26	82	0%	38	33	71	0%
45-49	134	81	215	1%	128	75	203	1%
50-54	396	197	593	3%	370	166	536	3%
55-59	1,115	536	1,651	7%	956	427	1,383	7%
60-64	2,350	1,281	3,631	16%	2,120	1,157	3,277	16%
65-69	3,372	1,894	5,266	24%	2,936	1,825	4,761	23%
70-74	2,870	1,734	4,604	21%	2,926	1,847	4,773	23%
75-79	1,779	951	2,730	12%	1,650	1,037	2,687	13%
80-84	1,372	732	2,104	9%	1,178	704	1,882	9%
85+	749	554	1,303	6%	723	511	1,234	6%
TOTAL	**14,211**	**8,002**	**22,213**	**100%**	**13,046**	**7,795**	**20,841**	**100%**

LUNG CANCER STAGE DISTRIBUTION

Lung cancer stage distribution at the time of diagnosis (Figure 7) was based on the literature.[20,21,22] Lung cancer progress through stages I, II, IIIA, IIIB and IV is in order without skipping any stages. The model does not distinguish histology, such as small cell or non-small cell lung cancers.

FIGURE 7: LUNG CANCER STAGING AT THE TIME OF CLINICAL PRESENTATION (STANDARD CLINICAL CARE—STATUS QUO)

Age group/ Stage of cancer	50-54	55-59	60-64	65-69	70-74	75-79	80+	TOTAL	50-74
I	20.5%	22.7%	26.8%	29.5%	30.2%	30.5%	27.2%	28.2%	28.0%
II	5.6%	6.2%	6.0%	6.7%	6.3%	6.2%	4.8%	6.2%	6.3%
IIIA	9.7%	9.8%	9.8%	10.2%	10.1%	9.9%	8.8%	9.9%	10.0%
IIIB	16.1%	16.3%	16.1%	15.4%	16.4%	17.2%	23.1%	16.9%	16.0%
IV	48.1%	45.0%	41.3%	38.2%	37.1%	36.1%	36.2%	39.0%	38.7%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Total stage distribution and stage distribution of modelled population aged 50 to 74 (last two columns of Figure 7) were estimated based on the number of lung cancer cases in Poland (Figure 5 above). The last column of Figure 7 provides a summary for the 50-74 age group that can be compared with the results of the screening model (Figure 12 below).

20. Chen, T., Zhou, F., Jiang, W., Mao, R., Zheng, H., Qin, L. & Chen, C. (June 2019). Age at Diagnosis Is a Heterogeneous Factor for Non-Small Cell Lung Cancer Patients. J Thorac Dis.;11(6):2251-2266. doi: 10.21037/jtd.2019.06.24. PMID: 31372262; PMCID: PMC6626822.

21. Austin, John H.M. et al. Small-Cell Carcinoma of the Lung Detected by CT Screening: Stage Distribution and Curability. Lung Cancer, Volume 76, Issue 3, 339 – 343.

22. Ten Haaf, K,, van Rosmalen, J. & de Koning, H.J. (January 2015). Lung Cancer Detectability by Test, Histology, Stage and Gender: Estimates From the NLST and the PLCO Trials. Cancer Epidemiol Biomarkers Prev.;24(1):154-61. doi: 10.1158/1055-9965.EPI-14-0745. Epub 2014 Oct 13. PMID: 25312998; PMCID: PMC4357842.

SCREENING PARAMETERS

Parameters of the screening were based on the work of F. Hofer et al.[23] Adherence rate was set at 100%, thus 100% participation in the program is assumed from the target group. Sensitivity of screening represents the probability of cancer detection depending on stage (Figure 8). For early recalls, i.e., in cases of follow-up screening in three-month period, sensitivity of cancer detection was defined for all lung cancer stages (Figure 9).

FIGURE 8: SENSITIVITY OF SCREENING

Stage	Healthy	Stage I	Stage II	Stage IIIA	Stage IIIB	Stage IV
Sensitivity	0	0.4339	0.4692	0.6910	0.7709	0.9781

FIGURE 9: INTERVAL FOLLOW-UP RATES

Early follow-up probability (1st round of screening)	0.2135
Sensitivity in early follow-up (1st round only)	0.0401 (all lung cancer stages)
Early follow-up probability (other rounds)	0.0453
Sensitivity in early follow-up (other rounds)	0.0963 (all lung cancer stages)

COST PARAMETERS

The cost of a national screening program for a target population is based on the PILOT screening program in Gdańsk with 8,649 participants in the 2009-2011 period.[24] In the PILOT study 3.5% of people screened went through an invasive diagnostic such as spirometry, biopsy or bronchofiberoscopy. Similar assumptions were applied in the model each year. Prices used for analysis were adjusted by the consumer price index (CPI) in health between year-end 2011 and July 2024 and rounded. All amounts are presented in PLN, i.e. Polish zloty (EUR 1 = PLN 4.3).

Model outcomes

The model provides information about the screening outcomes for participants in the screening program, including the frequency and number of screenings and follow-up procedures, changes in the population structure during the program, the quantitative impacts of screening on the number of lung cancer diagnoses, the stage distributions and mortality. This information, in combination with current medical cost estimates for screening, allows us to estimate the cost of a national screening program for a target population and simulate the distribution of cost-per-patient values. We do not examine the costs of treating diagnosed cancers.

23. Hofer, Kauczor & Stargardt (October 2018), op cit.

24. Rzyman, W., Szurowska, E. & Adamek, M. (May 2019). Implementation of Lung Cancer Screening at the National Level: Polish Example. Transl Lung Cancer Res.;8(Suppl 1):S95-S105. doi: 10.21037/tlcr.2019.03.09. PMID: 31211110; PMCID: PMC6546622.

STAGE DISTRIBUTION

Figure 10 presents the distribution of stages over five, 10 and 15 years of the screening program with comparison with the natural history stage distribution.

FIGURE 10: DISTRIBUTION OF STAGES OVER 5-,10- AND 15-YEAR PERIODS

		Natural history			Screening program		
Stage of cancer	KRN2020 (Figure 7)	5-year average	10-year average	15-year average	5-year average	10-year average	15-year average
I	28.0%	28.7%	28.6%	28.4%	72.7%	75.7%	77.7%
II	6.3%	5.5%	5.5%	5.7%	6.6%	6.3%	6.1%
IIIA	10.0%	7.4%	8.1%	8.6%	8.4%	8.3%	7.7%
IIIB	16.0%	15.8%	15.1%	15.7%	5.9%	4.8%	4.4%
IV	38.7%	42.6%	42.7%	41.7%	6.4%	4.9%	4.1%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

The average age at diagnosis and the diagnosed stage of lung cancer are lower in the presence of screening, resulting in a significant shift towards early-stage detection, particularly at stage I. These results directly impact the mortality of lung cancer, leading to higher survival rates and the potential for less complex treatments and aftercare. The most substantial impact is observed in the increase in early-stage (stage I) detections and the decrease in lung cancers detected at stage IV. In the long term, over three-quarters of all cases are detected at stage I. Among individuals for whom lung cancer was detected through screening, 83.88% were found at stage I or II, compared to the no-screening scenario where 66% were at stage III or IV.

EXPECTED GAIN IN LIFE-YEARS

The expected mortality gain is presented in Figure 12. Mortality loads were applied on an age, sex and stage basis based on the work of S. Goldberg et al.[25] (Figure 11). Mortality loads are applied as a multiplier to the standard annual probability of death. For years, before diagnosis a standard Polish mortality table adjusted for heavy smokers was used (Figure 4 above). We projected the expected number of lives in each year of projection and compared the accumulated life years.

FIGURE 11: MORTALITY LOAD BY STAGE, AGE GROUP AND SEX

Age group/ Stage of cancer	Female			Male		
	<65	65-74	75+	<65	65-74	75+
I	8.45	4.51	2.63	6.37	3.85	2.63
II	17.59	8.89	4.15	11.99	6.48	3.96
IIIA	36.34	15.42	7.47	23.23	11.36	5.72
IIIB	47.90	20.94	9.19	34.73	14.60	7.05
IV	97.13	34.59	13.37	62.65	22.79	9.68

25. Goldberg, S.W., Mulshine, J.L., Hagstrom, D. & Pyenson, B.S. (February 2010). An Actuarial Approach to Comparing Early Stage and Late Stage Lung Cancer Mortality and Survival. Popul Health Manag.;13(1):33-46. doi: 10.1089/pop.2009.0010. PMID: 20158322.

FIGURE 12: ACCUMULATED LIFE-YEARS GAIN ON MORTALITY FOR 100,000 COHORT AND TARGET POPULATION ELIGIBLE TO SCREENING IN POLAND

Life years gain	10-year	15-year
Perr 100,000 in target population	1,281	3,747
For target population	88,350	258,406

Over the course of a 15-year projection over a quarter of a million life-years are gained, which translates to 1.18 additional years of extra life years per each cancer case diagnosed. In the long run (adding years outside the 15-year projection) the screening program is estimated to add, on average, 3.74 extra life-years per each cancer case diagnosed.

Cost analysis

Unit prices are presented in Figure 13. A qualification visit is assumed to take place only once at admission to the program. The result visit is considered to occur after each CT scan to present results to each patient. Number of visits, diagnostic procedures and CT scans per 100,000 cohort in five-,10- and 15-year projection periods are presented in Figure 14. All costs are on a 2024 basis.

FIGURE 13: ASSUMED UNIT PRICES

Service	PLN
Qualification visit	60
Result visit after CT	100
Invasive diagnostics	3,500
CT scan	400

FIGURE 14: PROJECTED ANNUAL NUMBER OF VISITS, DIAGNOSTIC PROCEDURES AND CT SCANS FOR A 100,000 COHORT

	Screening program			
	Year 1	5-year average	10-year average	15-year average
Qualification visit	100,000	24,281	14,498	10,990
Result visit after CT	114,932	110,434	112,641	113,410
Invasive diagnostics	3,987	3,831	3,907	3,934
CT scan	114,932	110,434	112,641	113,410

The average annual cost of the national screening program in Poland was estimated at PLN 4.9 billion, i.e., approximately PLN 71 million per 100,000 cohort (Figure 15).

FIGURE 15: ESTIMATION OF THE ANNUAL COST OF THE NATIONAL SCREENING PROGRAM IN POLAND

	Screening program			
	Year 1	5-year average	10-year average	15-year average
For 100,000 cohort (in PLN mln)	77.5	70.1	70.9	71.1
For target population (in PLN bn)	5.3	4.8	4.9	4.9

The higher amount in year 1 results from one-off qualification visits at admission to the program. These figures do not consider the cost of treatment after diagnosis.

Discussion and limitations

For this study, we have combined established methodologies and the results of large-scale trials of lung cancer screening with demographic and cost data from Poland. The results suggest that screening programs can produce large gains in life expectancy for people who will be diagnosed with lung cancer.

As with any forecast, this work is subject to uncertainty about future events, especially those related to therapies (new detection methods) or population health (such as epidemics). This work is based on models that use factors and inputs. The clinical results of LCS are well-established, but the implementation of LCS in Poland can cause results to differ (better or worse) from those demonstrated in other countries. While we attempted to customise our models for the characteristics of Poland, the accuracy of our work depends on the accuracy of our sources. In particular, we note that the prices we assumed were based on available data and the national average prices could be higher or lower than we assumed. Artificial intelligence (AI) reading of digital images such as LDCT is advancing rapidly, which may improve the historical dynamics of LCS programs. The impacts of these and other changes are best done comprehensively, through rerunning the simulation.

Lung cancer therapies are evolving rapidly and the costs of treating late-stage lung cancers are expected to increase with the use of targeted therapies. These trends may mean that shifting to diagnosis at earlier stages will reduce spending, but we did not attempt to estimate such costs.

Disclosures

The American Academy of Actuaries requires its members to identify their credentials in their work product. Pyenson is a Fellow of the Society of Actuaries and a Member of the American Academy of Actuaries and meets its qualifications for this work. At the time this work was performed, he was a Principal and Consulting Actuary at Milliman.

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