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RESEARCH ARTICLE

Is Awareness of Low-Dose Computed Tomography (LDCT) Lung Cancer Screening Critical to Participation in Screening?

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Abstract

Background: Lung cancer is the second most common cancer and the leading cause of cancer death in the US. Yet, only 2-4% of Americans were eligible for screening reported obtaining chest CT screening for lung cancer. It is critical for both males and females to be aware of lung cancer screening for early diagnosis and treatment. The present study proposed to (1) explore levels of awareness and receipt of lung cancer screening and predisposing, enabling, and factors associated with receipt and (2) examine the relationship between lung cancer screening awareness and receipt of screening

Methods: A quota sampling strategy was used to recruit 242 aged 50 and above at the 2016 Minnesota State Fair. Data were collected through self-administered survey.

Results: Receipt of lung cancer screening was positively associated with age and number of routine doctor visits but was associated negatively with married or partnered status. Awareness of lung cancer screening was strongly linked to the receipt of lung cancer screening. Low awareness and low healthcare use were strongly linked to lower receipt of lung cancer screening.

Conclusion: Improving awareness of lung cancer screening and increasing the number of routine doctor visits may encourage at-risk individuals to actively engage in preventive lung cancer screenings, which in turn can reduce mortality from lung cancer in the US.

Keywords: lung cancer; screening; receipt; awareness; Andersen's behavioral model

Introduction

Lung cancer is the second most common cancer for both sexes and the leading cause of cancer death in the United States [1]. In 2019, lung cancer accounted for 25% of all cancer deaths [1]. Although lung cancer has an aggressive nature, the National Lung Screening Trial Research (NLST) indicated screening with low-dose computed tomography (LDCT) reduced the mortality from lung cancer by 18-20% among members of both sexes who had smoked for thirty or more years [2, 3]. Nonetheless, one study showed only 2-4% of eligible Americans reported receiving a chest CT for lung cancer screening [3, 4]. Increasing awareness and utilization of lung cancer screening opportunities is considered critical to improving early diagnosis rates and treatment effectiveness [5, 6]. To guide efforts in addressing this concern, this article reports the findings of a survey exploring factors related to awareness and receipt of lung cancer screening.

Risks and Benefits of Lung Cancer Screening

Although LDCT is considered a beneficial advancement in lung cancer detection, there are potential risks. Concerns regarding the use of LDCT for lung cancer screening include 1) false-positive results [4, 7-15] which increase patients' psychological and physical burdens, 2) indeterminate results [16] which prompt additional tests, and 3) radiation exposure [4, 7-10, 12, 14, 16]. Croswell and colleagues [17] found there was a 21% cumulative probability of at least one false-positive result after one screening and 33% after two screenings. Research also showed annual LDCT lung cancer screening would increase lifetime incidence of lung cancer by 1.8% among current and former smokers 50-75 years old [8].

Despite these risks, LDCT for lung cancer screening has shown promising outcomes for early detection and diagnosis. Annual LDCT screening reduced the relative risk of death from lung cancer by 20% among a high-risk population [7, 9, 16]. Prior studies also indicated that lung cancer screening improved

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patients' quality of life by reducing disease- and treatment-related morbidity, promoting healthy lifestyles, and reducing patients' anxiety and other psychosocial burdens of lung cancer [13, 16, 18]. Also, lung cancer screening can motivate patients to cease smoking [18]. Lung cancer screening is also cost-effective, [16] especially when considering the high cost of lung cancer treatment at advanced stages [19]. In light of these benefits, both the United States Preventive Services Task Force and the American Cancer Society (ACS) recommend LDCT for patients 55 to 74 years old with more than 30 pack-years of smoking history who are current smokers or have quit smoking within the past fifteen years [14].

Lung Cancer Screening Awareness

Despite the benefits of lung cancer screening, efforts to increase awareness among healthcare providers, healthcare systems, and patients of lung cancer screening have yet to be sufficiently implemented [12, 18, 20]. Most patients who are eligible for lung cancer screening show a lack of awareness and/or low literacy of lung cancer screening guidelines [18]. Furthermore, Carter-Harris and colleagues [18] revealed that even those patients who had received lung cancer screening presented some degrees of confusion on how lung cancer screening was performed. Lack of awareness of lung cancer symptoms and screening is one the most important factors explaining why many patients present with advanced symptoms of lung cancer [5, 12].

Hart and colleagues also found that a lack of healthcare provider awareness resulted in underutilization of lung cancer screening tools in clinical practice [12]. Additionally, communication between patients and healthcare providers about lung cancer screening was found to be less frequent than discussions of other types of cancer screening [9]. Health knowledge interrelated to lung cancer screening is relatively lower than other types of cancer, and the awareness of lung cancer risk remains subprime among smokers with long-term smoking history [18]. Hence, raising awareness of information regarding lung cancer screening is recognized as having a similar level of importance as the availability of lung cancer screening [9].

To improve awareness, it is crucial to examine potential factors associated with awareness of lung cancer screening among eligible patients [18]. To our knowledge, however, the present study is the first study to examine risk factors related to behavioral health of lung cancer screening receipt among the general adult population.

The Present Study

Although lung cancer screening awareness was mentioned in several previous studies, the empirical evidence of lung cancer screening awareness and its influence on receipt has not been fully explored. Hence, the present study was designed to investigate the relationship between awareness and receipt of lung cancer screening, as well as factors associated with the receipt among the general adult population. In particular, this study looks at how lung cancer screening awareness is associated with the receipt of the screening. Therefore, the research questions of the present study were as follows:

(1) What are the levels of the receipt of lung cancer screening?

(2) What is the relationship between lung cancer screening awareness and the receipt of screening while controlling for relevant variables?

Conceptual Framework

The present study applied Andersen's behavioral model as the conceptual framework. Andersen's model was designed to examine and predict healthcare service utilization by identifying predisposing characteristics, enabling resources, and need variables [21-24]. The expanded Andersen's behavioral model is widely used to explore different types of health behaviors and health service utilization, and to understand the predictors of participation in cancer screening, health literacy, and annual health check-ups [25, 26].

According to Andersen's behavioral model, predisposing factors refer to demographic characteristics, such as gender, race, and marital status, as well as health beliefs, such as health knowledge and a patient's values and attitudes toward healthcare services [24-27]. An enabling factor is one which could influence access to healthcare services, such as financial resources [26, 27]. Need factors refer to an individual's health status and perceptions of functional capacity and coping abilities which would influence their need for medical care and services [25, 27, 28].

The present study included the predisposing factors of age, gender, marital status. The six enabling factors were educational attainment, monthly household income, annual health check-up, health literacy, the number of doctor visits, and cancer screening awareness. Health insurance, family cancer history, and self-reported health status were considered as need factors which could motivate individuals' health behaviors and seek for professional health service. Identifying the predisposing, enabling, and need factors that were most predictive of lung cancer awareness and receipt can guide development of lung cancer screening promotion.

Method

Design and Sample

Upon receiving approval from the University of Minnesota Institutional Review Board (IRB), 733 adults aged 18 years or older were recruited at the 2016 Minnesota State Fair. A survey on receipt of lung cancer screening and health behavior was administered and recorded by using REDCap, HIPAA-compliant data collection software on iPads. Participants received a small gift (a backpack that could be used at the fair) for completing the survey as a token of appreciation for their time. Of the adults who participated in the survey, 242 were aged 50 and above and included in the analysis for the factors associated with lung cancer screening receipt.

Measures

The dependent variable for this study was receipt of lung cancer screening, which is a binary variable (yes/no). Participants were asked "Have you ever had CT chest for lung cancer screening?"

Predictor variables were identified and categorized using Andersen's health behavior model as a theoretical framework [22]. As stated above, this model proposes that health outcomes are predicted by predisposed, enabling, and need factors. In this study, predisposing factors included gender, age group, and marital status. For gender, respondents were categorized as male or female. Respondents were asked to enter their actual age in years and were subsequently divided into three age groups for analysis: (1) 50-59 years old; (2) 60-69 years old; and (3) 70 years old or older. Marital status was collapsed into a dichotomous variable consisting of either married or partnered, or all other as a reference group.

Enabling factors included education level, monthly household income, participation in annual health check-ups, frequency of doctor visits, and lung cancer awareness. Education level was analyzed as a dichotomous variable consisting of having a bachelor's degree or not. Monthly household income was divided into three groups: (1) less than $5,000; (2) between $5,000 and $9,999; and (3) $10,000 or more. Binary values of attending annual health check-ups (yes/no) were analyzed. Number of doctor visits was categorized into three groups: (1) once a year or less; (2) once or twice per six months; and (3) once every two months or more. The last enabling variable was awareness of lung cancer screening which was a dichotomous variable by yes/no.

Need factors included health insurance, family cancer history, and self-reported health status. Binary values were used to analyze health insurance, which asked whether participants had insurance (yes/no). For family cancer history, participants were asked whether their family ever had cancer of any kind (yes/no). For self-reported health status, respondents were asked how they would rate their health on a 5-point scale from "1" being very poor to "5" being excellent or very good. This was analyzed as a dichotomous variable consisting of either (1) very poor/poor/fair and (2) good/excellent or very good in the study.

Analytic Strategy

Univariate and bivariate analyses were employed to examine the demographic characteristics of participants and their association with the receipt of lung cancer screening. Crosstab with Chi-square analysis was also conducted to compare the reported proportions of those who were aware of and had received lung cancer screening. Multiple logistic regression analysis was also used to investigate how predisposing, enabling, and need factors were associated with receipt of lung cancer screening. A logistic regression analysis was conducted in this study due to the binary values (0 = no or 1 = yes) of the outcome variables.

The SPSS 25.0 software package was used with 5% set as the statistical significance threshold for all data analyses.

Results

Socio-Demographic Characteristics and Bivariate Analysis

Table 1 summarizes the socio-demographic characteristics of the study sample. The first column reports the number of respondents and the corresponding percentage for each

Table 1: Summary of Socio-demographic Characteristics of the Study Sample (*N* = 242)

Variables	*n*[a] (%)	Receipt of Lung Cancer Screening	
		n (%)	p-value[b]
Predisposing Factors			
Age (Mean = 60.24 yrs)			
50yrs—59yrs	120 (49.6%)	13 (11.9%)	**.01**
60yrs—69yrs	105 (43.4%)	23 (25.8%)	
70yrs and over	17 (7.0%)	5 (38.5%)	
Gender			
Male	103 (42.6%)	17 (17.5%)	.519
Female	139 (57.4%)	24 (21.1%)	
Marital Status			
Never married or other	80 (33.1%)	21 (30.9%)	**.007**
Married or partnered	153 (63.2%)	20 (14.7%)	
Enabling Factors			
Education			
<Bachelor's degree	62 (25.6%)	10 (19.6%)	.971
≥Bachelor's degree	179 (74.0%)	31 (19.4%)	
Monthly household income (US$)			
Less than $5000	30 (12.4%)	6 (24.0%)	.822
$5000-$9999	25 (10.3%)	4 (17.4%)	
$10,000 or more	177 (73.1%)	30 (19.2%)	
Annual Health Check-up			
No	33 (13.6%)	3 (10.3%)	.179
Yes	207 (85.5%)	38 (21.0%)	
Number of doctor visit			
Once a year or less	146 (60.3%)	19 (14.8%)	**.019**
Once/twice for 6 months	76 (31.4%)	14 (21.5%)	
Once every 2 months or more	14 (5.8%)	6 (46.2%)	
Need Factors			
Health insurance			
No	9 (3.7%)	2 (28.6%)	.514
Yes	231 (95.5%)	38 (18.7%)	
Family cancer history			
No	41 (16.9%)	8 (21.1%)	.728
Yes	199 (82.2%)	32 (18.6%)	
Self-reported Health Status			
Very poor/poor/fair	33 (13.6%)	10 (32.3%)	**.042**
Good/very good/excellent	207 (85.5%)	30 (16.8%)	

[a] The total sample size of each variable may not be the same as the total sample size of the study due to missing values.
[b] t-test p-values for binary variables and F-test p-values for categorical variables with more than two values.

variable. The second and third columns show the number and percent of the individuals within each sociodemographic group reporting awareness and receipt of lung cancer screening along with *p*-values of the x^2 tests comparing these proportions within each category.

The average age of the sample population was 60.24 years old. Approximately half of the participants were 50 to 59 years, and 43% of sample was at 60 to 69 years. Only 7% of participants were over 70 years old. Rate of receiving lung cancer screening was significantly associated with age. There were more females (57.4%) in the sample than males, but gender was not significantly associated with the receipt of lung cancer screening. Receipt of lung cancer screening significantly differed by marital status. Sixty-three percent of the sample was married or partnered; those who were married or partnered had a lower rate of LDCT screening participation (14.7%) than those who were unmarried (30.9%).

Seventy-four percent of the sample had a bachelor's degree or higher level of education. In regard to household income, the majority of participants (73.1%) had more than US$10,000 monthly household income. The table shows that 85.5% of participants attended annual health check-ups. Moreover, 60.3% visited a doctor once a year or less, while 31.4% visited a doctor once or twice every six months and 9.4% visited a doctor once or more every two months. The present study showed that the number of doctor visits was significantly associated with receipt of lung cancer screening (*p = 0.019*) and people who visited their doctors once every two months or more had the highest rate of the receipt of lung cancer screening (46.2%).

Approximately 96% of participants had health insurance, and 82.2% of particiapnts reported that their family had experienced cancer of any kind. Health insurance and family cancer history were not significantly related to the receipt of lung cancer screening. Approximately 85% of participants rated their health status as good, very good, or excellent. Self-reported health status was significantly related to the receipt of lung cancer screening ($p = 0.042$) with those who rated their health status as very poor/poor/fair had a higher rate of screening (32.3%). (Table 1)

Receipt of Lung Cancer Screening

Regarding the receipt of lung cancer screening among the participants (Table 2), 19.4% had received LDCT chest for lung cancer screening. Among those who had lung cancer screening, 58.65% of respondents reported that they had it five or more years prior. (Table 2)

Multiple Logistic Regression Analysis

Table 3 reports multiple logistic regression analyses of factors associated with the receipt of lung cancer screening.

Two predisposing factors significantly predicting the receipt of lung cancer screening were age and marital status. Particularly, compared to participants aged 50-59 years old, participants aged 60-69 years old (*OR = 2.976, 95% CI = 1.201-7.370*) and aged above 70 years (*OR = 8.416, 95% CI = 1.786-39.653*) were more likely to have lung cancer screening. Participants who were married or partnered were significantly less likely to have had lung cancer screening (*OR = 0.422, 95% CI = 0.180-0.990*).

Two enabling factors significantly predicted the receipt of lung cancer screening. Those factors were the number of doctor visits and awareness of lung cancer screening. Compared to participants who visited a doctor once a year or less, those who visited a doctor once every 2 months or more were more likely to have lung cancer screening (*OR = 5.869, 95% CI = 1.169-29.465*). In addition, the probability of having lung cancer screening is higher among participants who aware of lung cancer screening (*OR = 25.147, 95% CI = 3.090-204.672*). None of the regression coefficients for the need factors reached statistical significance. (Table 3)

Discussion

The present study analyzed lung cancer screening awareness and receipt through the perspective of Andersen's behavioral model, which highlights predisposing factors, enabling factors, and need factors in health behavior. Several factors related to individuals' receipt of lung cancer screening was identified in the present study while others were shown to be inconsequential.

The current study's findings suggested that individuals at the younger end of the recommended age range for lung cancer screening were less likely to have received lung cancer screening. It is possible that patients' knowledge and attitudes toward lung cancer screening improves with increasing age, which may be a consequence of experiencing other health issues that accompanies increasing age. It is also possible that healthcare providers are more likely to recommend lung cancer screening for older patients. Additionally, married participants were less likely to receipt of LDCT lung cancer

Table 2: Receipt of Lung Cancer Screening

	50-59 (n=110)		60-69 (n=96)		70 and over (n=15)		Total (n=221)	
Receipt (Yes)	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
	13	11.9	23	25.8	5	38.5	41	19.4
< 1 yr ago	1	4.3	2	7.1	0	0.0	3	5.2
≥ 1 yr ago < 2 yrs ago	5	21.7	6	21.4	2	28.6	13	22.4
≥ 2 yrs ago < 3 yrs ago	1	4.3	2	7.1	1	14.3	4	6.9
≥ 3 yrs ago < 5 yrs ago	1	4.3	1	3.6	2	28.6	4	6.9
≥ 5 yrs ago	15	65.2	17	60.7	2	28.6	34	58.6

Table 3: Logistic Regression Analysis

Variables	Model 1		Model 2		Model 3	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Predisposed Factors						
Age (Ref=50yrs – 59yrs)		**.017***	2.536 (1.070, 6.011)	**.035***	2.976 (1.201, 7.370)	**.018***
60yrs – 69yrs	2.639 (1.193, 5.838)					
70yrs and above	5.89 (1.543, 22.483)	**.009****	6.443 (1.483, 27.985)	**.013***	8.416 (1.786, 39.653)	**.007****
Gender (Ref = Male)	1.061 (.503, 2.234)	.877	1.015 (.451, 2.287)	.971	.898 (.391, 2.063)	.800
Marital Status (Ref = Never married or other)	358 (.169, 758)	.007	.404 (.175, .933)	**.034***	.422 (.180, .990)	**.047***
Enabling Factors						
Education (Ref = < Bachelor's degree)			1.081 (.419, 2.789)	.873	1.149 (.443, 2.977)	.776
Monthly Household Income $5,000-$9,999 (Ref=Less than $5,000) $10,000 or more			1.542 (.650, 3.658)	.326	1.109 (.425, 2.892)	.704
Number of Doctor Visit (Ref = Once a year or less)			6.600 (1.377, 31.625)	**.018***	5.869 (1.169, 29.465)	**.019***
Awareness (Ref = No)			25.056 (3.094, 202.877)	**.003****	25.147 (3.090, 204.672)	**.003****
Need Factors						
Health insurance (Ref=No)					.728 (.064, 8.277)	.798
Health status (Ref = Very bad/bad/fair)					.360 (.114, 1.140)	.082
Good/very good/excellent Family History (Ref = No)					.881 (.296, 2.623)	.819
Number of observations	190		190		190	
Wald Chi-Square	9.914		7.845		9.124	
Pseudo R^2	.131		.323		.343	
Hosmer-Lemeshow goodness-of-fit test	.209		.242		.990	

screening compared to those who were unmarried participants considering the present study. One plausible explanation is that unmarried participants are more likely to concern about their health when they are aged so that more likely to search for cancer screening methods that promote health and longevity [29].

Considering the present study, the findings indicate that unawareness of lung cancer screening and fewer doctor visits may serve as primary barriers to the receipt of lung cancer screening. Participants who had heard of lung cancer screening were significantly more likely to receive lung cancer screening. This finding adds to previous studies that have suggested increased health and cancer literacy can promote cancer screening use [25, 26, 30]. Limited knowledge about cancer and cancer symptoms has been found to contribute to the lack of desire for cancer screening and the low receipt of cancer care [30, 31]. Our study provides evidence that basic awareness of screening options is also strongly associated with receipt of cancer screening, particularly regarding lung cancer screening. Also, a decreased number of doctor visits significantly predicted not receiving lung cancer screening. This finding is consistent with the extant literature, which has reported that healthcare providers take the critical role of facilitating their patients' awareness and use of lung cancer screening [32]. Therefore, the present study indicated that a regular doctor visit or routine health check-up could improve the cancer literacy or heath literacy [26] and increase the opportunity to receive more health-related information so that increase the awareness and receipt of lung cancer screening. Healthcare providers and professionals should encourage their patients to establish a routine health check-up or visit their primary physicians regularly.

Limitations

There are two main limitations that should be considered in the present study. First, the current study is a cross-sectional survey which is not able to examine the causal relationship between predictive factors and the awareness or receipt of lung cancer screening. Additional studies might conduct longitudinal research to better explore and understand the causal direction of the relationships identified here. Second, this study employed a convenience sample from one state and a small sample size of participants who were older than 70 years. Therefore, the results yielded by the present study may not represent the general population across that state or the nation. Future studies applying a national representative sample to investigate the factors of lung cancer screening awareness and receipt would be beneficial.

Conclusion

Overall, the results suggest awareness of lung cancer screening and adherence to routine doctor visits may play an important role in increasing rates of lung cancer screening. Community-based education programs on screening and reinforcing clinician training with its importance may effectively improve patients' lung cancer screening utilization [6]. Special consideration should be given to the younger senior population which tended to have lower levels of awareness and screening participation. Healthcare providers could develop a targeted approach to counsel eligible middle-aged adults about lung cancer screening and its role in reducing lung cancer burden. Promoting those individuals who are at risk for lung cancer to actively engage in preventive lung cancer screenings is critical to reducing mortality from lung cancer in the United States.

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