Mobile Phone Based Healthcare Platform for Assisting Lung Cancer Prevention

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Abstract: We developed a personal interactive management platform based on Android system called lung cancer prevention assistant. A mathematical model for quantifying the cancer occurrence risk was established. This healthcare system collects user's lifestyle events, such as tobacco smoking and diet structure, as input parameters. After comprehensive and quantitative analysis, the system would figure out the relative risk (RR) value of lung cancer morbidity and suggest guiding tips for lung cancer prevention. People with Android smart mobile phone or PDA (Personal Digital Assistant, such as widely used Pad) can access this management system easily, with the fact that Android smart phone is widely used over the world. This may possibly reduce the cost of medicine paid on the treatment and recovery of cancer. Advantages and possible applications of the present system were outlined. We also discussed the shortage of the lung cancer prevention assistant and suggest its potential solutions in the near future.

Keywords: Lung cancer prevention, Android, Health management system, Mobile health.

1. INTRODUCTION

The worldwide lung cancer had become one of the leading causes of preventable death, at the end of the 20th century [1]. In China, the cases of lung cancer have increased by 50%, from the mid-1970s to early 1990s [2]. Researchers and medical practitioners have long focused on cancer prevention. The fact that only 5–10% of all cancer cases are due to genetic defects and that the remaining 90–95% are due to lifestyle factors (including smoking, diet, alcohol, physical inactivity, obesity and sun exposure), infections and environmental pollutants provides major opportunities for preventing cancer [3]. Furthermore, tobacco smoking remains the major risk factor on the incidence of cancer, with 90% of all lung cancers occurring in smokers [1]. Besides the well-known cause (tobacco smoking), beginning in the 1980s, associations of diet with lung cancer risk have been vigorously investigated [1]. Large number of epidemiological studies focused on one or several exposure factors on the incidence of lung cancer. All these studies point out that non-smoking and healthy diet is helpful to cancer prevention. Actually, maybe everyone agree that this conclusion is self-evident. However, until today there is still no an effective method to achieve this goal. Clearly, smoking is harmful to health. But people would always just forget to quit smoking. And they do not have a quantitative understanding of how harmful of smoking to the lung. Aiming to provide an auxiliary tool to help people prevent lung cancer, here we developed for the first time an interactive method and software based on Android system, which can be used in mobile phone for such purpose. After given two parameters, family lung cancer history and the smoking history, the lung cancer prevention assistant system would figure out a RR value as user's initial record. After that, user could use the system to record exposure factors, which he or she has been exposed to daily, and the application will calculate RR value. In this case, the history of RR value can be displayed as a curve. So that user can find out how his or her RR value changes day by day. In this way, a better health care management can be carried out day and night.

2. PRINCIPLE AND METHOD

2.1. About Relative Risk (RR)

In statistics and mathematical epidemiology, RR is a measure of association between exposure to a particular factor and risk of a certain outcome. The RR is defined to be the ratio of risk in the exposed and unexposed groups. RR is a ratio of the probability of the event occurring in the exposed group versus unexposed group, i.e.

$$RR = \frac{p_{\exp osed}}{p_{un\exp osed}} \quad (1)$$

An equivalent term for RR that is sometimes used in epidemiology is the cumulative incidence ratio, which may be calculated as follows: RR is equal to the risk among exposed subjects divided by the risk among unexposed subjects [4], i.e.

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$$RR = \frac{I_e}{I_u} \quad (2)$$

where, I_e is exposed group mortality, I_u indicates unexposed group mortality. Considering lung cancer as an example, RR=1 represents no association between lung cancer and the studied exposure factor. RR>1 represents a positive correlation between lung cancer and the exposure factor. That is to say, the studied exposure increases the risk of lung cancer. RR<1 represents a negative correlation between lung cancer and the studied exposure factor. In other words, the exposure factor decreases the risk for lung cancer [5]. Generally, exposure factor, with RR less than 1, is healthy, and exposure factor, with RR more than 1, is harmful.

2.2. Exposure Factor of Interest

Lung cancer was first recognized in the late 19th century because of mineworkers of Germany's fatal disorder of lung. At decades, lung cancer was recognized as an occupational disease [2]. The occupational factors generally would cause air pollution. In other words, certain air pollution is a high-risk factor for lung cancer. However, considering the calculation limitation of mobile phone, we ignored the factor of air pollution. Until a case controlled study was published by Muller in 1940, in Germany, in which a statement was made that tobacco smoking was the single most important cause of the rising incidence of lung cancer [2]. It is believed that 90% of lung cancer cases are due to lifestyle factors, such as smoking and diet, which are controllable however. In order to find out the initial RR value, we also consider the history of family lung cancer.

2.3. Smoking-Related RR

Tobacco smoking or cigarette smoking (smoking for short) is the major cause of lung cancer. Relative risk of lung cancer increases with quantity of cigarettes smoked, duration of smoking, and depth of inhalation. Also smoking start age and years of smoking cessation affect the RR. A meta-analysis of studies on the association between smoking and risk of lung cancer is published by Wang *et al.* [6]. We mainly used the RR value in their paper. Additionally, for simplicity, we ignored the confidence interval and only use the maximum likelihood value of RR for the analysis (Table **1**).

Table 1: Relative Risks (RR) of Lung Cancer—Association Between Lung Cancer and Smoking [6]

Item	Status	RR
Age started	<15	13.31
	15-20	7.21
	>20	4.74
Duration (years)	<20	1.25
	20-40	5.10
	>40	10.77
Number of cigarettes/day	<10	1.97
	10-20	5.20
	20-40	7.46
	>40	15.14
Inhalation	No	3.26
	Yes	8.07
Years of smoking cessation	<10	7.16
	10-20	2.12
	>20	1.47

2.4. Diet-Related RR

There have many studies to assess the association between dietary intakes and risk of lung cancer. The World Cancer Research Fund (WCRF) has done significant work for cancer prevention. The book Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective is much valuable to both researchers and general people. Thanks to their work, we mainly summarized the association between risk of lung cancer and diet from there (Table **2**).

Table 2: Relative Risks (RR) of Lung Cancer—Association Between Lung Cancer and Diet [7]

Food	RR
Green leafy vegetables [8]	0.50
Cruciferous vegetables [9]	0.67
Fruits	0.80
Dietary carotenoids	0.74
Dietary flavonoids	0.42
Processed meat	1.6
Red meat	1.03

2.5. History of Family Lung Cancer-Related RR

A systematic review finds a significant increase of lung cancer risk associated with history of family lung

cancer [10]. Difference of risk between smoker and non-smoker has also been recognized. But the difference is small enough to be ignored. Table **3** illustrates RR association between history of family lung cancer and morbidity of lung cancer.

Table 3: Relative Risks (RR) of Lung Cancer—Association Between Lung Cancer and History of Family Lung Cancer [10]

History of Family lung cancer	RR
No	1
Yes	1.84

2.6. Determination of Initial RR Value

As mentioned above, we use two factors, smoking history and the history of family lung cancer, to figure out the initialization RR value. Different state of smoking means different association with the risk of lung cancer. To obtain the detailed smoking history, a questionnaire is used which is illustrated by Figure **1**.

Here, we treat RR value as probability. According to the basic probability theory, the probability of two independent events is the product of the probability of the two events respectively. Based on this hypothesis, initial RR is calculated as:

$$RR_{ini} = RR_{som} \times RR_{flh} \quad (3)$$

where, RR_{ini} is initial RR value and RR_{som} is the RR value decided by smoking history (Table **1**), and RR_{flh} is the RR value decided by history of family lung cancer (Table **3**).

Different smoking status, for instance smoking duration less than 20 years (RR=1.25) and starting smoking before 15 years old (RR=13.31), represent different RR value (Table **1**). We use the maximum value as RR_{som} value. Obviously, if smoking history is none, RR_{som} would be 1. As to RR_{flh} value, it is 1.84 with the history of family lung cancer and 1 without the history of family lung cancer.

2.7. Calculation of Daily RR

We are interested in several exposure factors such as smoking amount and diet content (Table **2**) every day. Let EF_i (i for 1 to n) donates a special exposure factor, and RR_i donates its RR value. Otherwise, RR_i equals to 1. Let RRD_k donates today's RR, and RRD_{k-1} is yesterday's RR. One can then calculate today's RR using the following formula:

$$RRD_k = RRD_{k-1} + \log\left(\prod_{i=1}^{n} RR_i\right) \quad (4)$$

Clearly, if user is exposed to exposure factor EF_i, RR_i is the value as show in Table **1** or Table **2**.

3. APPLICATION DEMONSTRATION

Based on the above principle, we developed an application system based on Android platform, which achieved the major features as described above. Here, considering the application is mainly tested in our local

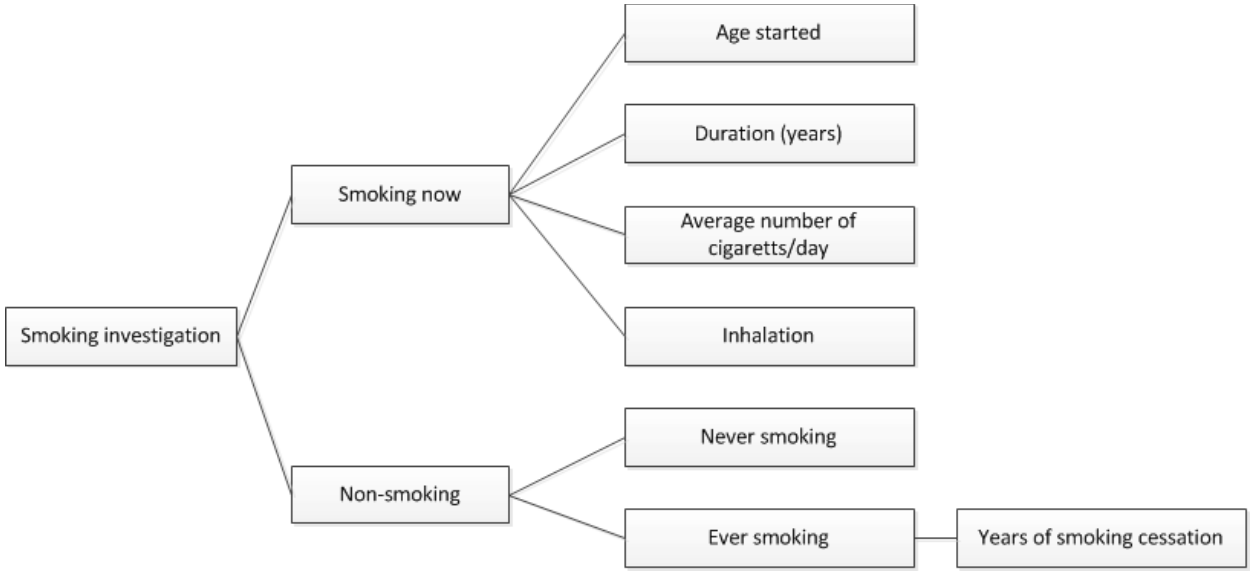

Figure 1: Investigation of smoking history.

areas, the present software is developed with user interface in Chinese. We expect to convert it into English in the coming time. In this paper, we would explain the corresponding meanings of the software operations by the words in the text. In order to protect personal privacy data, user with both right user name and password can access the application (Figure **2**). There is another tab UI besides the login tab as Figure **2** illustrated in Chinese characters. This tab contents some fundamental knowledge about lung cancer prevention, which is “What is lung cancer”, “Lung cancer can be prevented” and “How to prevent lung cancer”. Without log in, user can have a review about lung cancer prevention, which will help people to keep away from lung cancer.

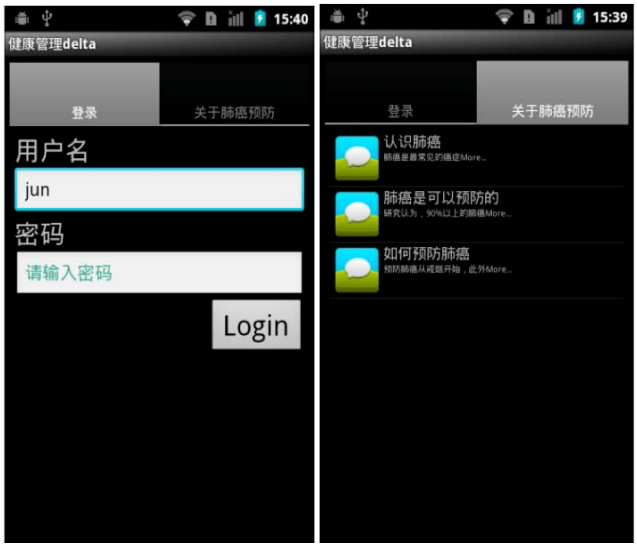

Figure 2: Login screen and lung cancer prevention interface.

Suppose Jun is a new user. He input his name Jun in the user name box, and let the password to be null, which is also supported. First of all, Jun wants to enter his personal data like history of smoking and the family lung cancer history (Figure **3**). As Figure **3** shows, Jun can still learn some knowledge about lung cancer prevention after login. Suppose Jun has never smoked but his father suffered from lung cancer unfortunately. After he entered this information, His initialization RR value will be 1.84. RR will be shown in the Daily Investigation tab page (Figure **4**).

After then Jun needs to click the New Record button to finish the investigation every day. The investigation items include smoking amount and diet content (Table **2**). After the New Record button was clicked, Jun wants to set today’s date. The date of the system will be shown for easy use (Figure **5**).

Figure 3: Personal data management interface.

Figure 4: Daily investigation tab page.

Figure 5: Set date.

Figure 6: Investigation screen.

In most cases, the OK button can be clicked. There are several pages for investigating. The first page is about smoking amount. Jun smoked three cigarettes today, so he puts 3 in the input box. Jun can slides left or right to switch to another page (Figure **6**). After investigation, Jun clicks the Done button. The new RR value will be displayed in the Daily Investigation tab page.

And the history RR value can be depicted as a 2D discrete figure (Figure **7**). Jun only needs to click the Show History button.

4. DISCUSSION AND CONCLUSION

An effective way to prevent lung cancer is to identify the numerous exposures that are causally associated with lung cancer. If steps can be taken to reduce or eliminate the population's exposure to these agents, this would be expected to reduce the population's risk of lung cancer [11]. Daily lifestyle especially cigarette smoking is causally associated with lung cancer [12-17]. Mobile phone or e-health has shown promise in helping healthcare in now individual medical healthcare era [18-20].

The most advantage of the lung cancer prevention assistant system is that it at least can give people a quantitative concept of daily life associated with lung cancer morbidity ignoring the accuracy of quantitative RR. Besides, the record of daily life is a prompt for people to give up smoking and develop a healthy diet plan. With such prevention tips, people can manage

Figure 7: History of RR value.

their life more easily and rationally. In this sense, it would definitely help improve one's lifestyle.

However, there does exists certain shortages in this lung cancer prevention assistant system so far. First of all, the exposure factors associated with lung cancer morbidity, which were considered in this paper, are still far away from completeness. Food contamination and air pollution are partly associated with lung cancer morbidity. Especially occupational pneumoconiosis, because of long-term inhalation of dust, tends to lead to lung cancer easily without effective prevention methods. The RR value of each exposure factor may not be applicable to every people because of the differences in the structure of diet nutrition, which was mainly caused by regional differences. We ignore the regional differences when collecting RR value. This will increase the uncertainty of the assessment. The accuracy of the assessment result cannot be guaranteed, because of the obvious reason that the RR value of each exposure factor we got from the research papers is a long-term accumulation of this exposure factor acting on people. However, we used it to estimate everyday relative risk. These factors mentioned above have increased the uncertainty of the assessment. For brievity, we have not done additional work to evaluate the accuracy of the assessment results which needs large scale clinical test.

Theoretically speaking, more variant associated factors can be involved in the system. It is obvious that the more the lung cancer occurrence related factors are included, the more accurate the estimated everyday relative risk will be. As to environmental factors, we have not found so far any published papers regarding cohort study on the data contributing to lung cancer occurrence risk. Therefore at this stage, we still can not get such Related Risk (RR) value, which is highly depended by the analysis. Nonetheless, the environmental factors can be included in the software application. For instance, one can propose some recommendations on outdoor activities based on local Air Pollution Index. It is of no doubt that occupational carcinogens are serious threats to relevant workers. However, occupational factors are uncontrollable unless those people change their jobs. It is believed that everyday protective methods are the most effective way to protect relevant workers. This study still did not consider the lifestyle to estimate the initial RR considering that it is not easy to get the history detail lifestyle such as diet construction. The quantitative model in the present system is not perfect. Its accuracy can be improved by a well-designed randomized control trial in the future along this direction.

Future work would be like testing the effects on people who use the lung cancer prevention system. The effects should include both the accuracy of assessment results and the smoking cessation rate. If this management system was demonstrated to work well, one can extend the method to other kinds of cancer. The present paper suggests a generalized mobile health care way for future cancer prevention.

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REFERENCES

[1] Pirozynski M. 100 years of lung cancer. Respirat Med 2006; 100: 2073-84. http://dx.doi.org/10.1016/j.rmed.2006.09.002

[2] Zou X-N. Epidemiology of lung cancer in China. Chin J Cancer Prev Treat 2007; 14: 881-83.

[3] Gonzalez A, Riboli E. Diet and cancer prevention: Contributions from the European prospective investigation into cancer and nutrition (EPIC) study. Eur J Cancer 2010; 46: 2555-62. http://dx.doi.org/10.1016/j.ejca.2010.07.025

[4] Sistrom L, Garvan CW. Proportions, odds, and risk. Radiology 2004; 230: 12-19. http://dx.doi.org/10.1148/radiol.2301031028

[5] Fu H. Preventive Medicine. People's Medical Publishing House 2006; 243.

[6] Wang DM, Li WM, Chen WB. Meta-analysis of studies on lung cancer risk and tabocco smoking. Chin J Resp Crit Care Med 2009; 8: 229-33.

[7] World Cancer Research Fund / American Institute for Cancer Research. Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective. Washington, DC: AICR, 2007.

[8] Dosil-Diaz O, Ruano-Ravina A, Gestal-Otero JJ, Barros-Dios JM. Consumption of fruit and vegetables and risk of lung cancer: A case-control study in Galicia, Spain. Nutrition 2008; 24: 407-13. http://dx.doi.org/10.1016/j.nut.2008.01.005

[9] Brennan P, Hsu CC, Moullan N, *et al.* Effect of cruciferous vegetables on lung cancer in patients stratified by genetic status: A mendelian randomisation approach. Lancet 2005; 366: 1558-60. http://dx.doi.org/10.1016/S0140-6736(05)67628-3

[10] Matakidou A, Eisen T, Houlston RS. Systematic review of the relationship between family history and lung cancer risk. Br J Cancer 2005; 93: 825-33. http://dx.doi.org/10.1038/sj.bjc.6602769

[11] Alberg J, Samet JM. Epidemiology of lung cancer. Chest 2003; 123: 21S-49S. http://dx.doi.org/10.1378/chest.123.1_suppl.21S

[12] Jiao SC. Lifestyle and cancer prevention. J Health Care Med Chin PLA 2005; 7(2): 72-74.

[13] Roswalla N, Olsena A, Christensena J, Dragsted LO, Overvad K, Tjønneland A. Source-specific effects of

micronutrients in lung cancer prevention. Lung Cancer 2010; 67: 275-81. http://dx.doi.org/10.1016/j.lungcan.2009.11.010

[14] Rachtan J. Smoking, passive smoking and lung cancer cell types among women in Poland. Lung Cancer 2002; 35: 129-36. http://dx.doi.org/10.1016/S0169-5002(01)00330-0

[15] Siegel R, Ward E, Brawley O, Jemal A. The impact of eliminating socioeconomic and racial disparities on premature cancer deaths. Cancer Statistics 2011; 61: 212-36.

[16] Corrales-Rodriguez L, Blais N. Lung cancer associated venous thromboembolic disease: A comprehensive review. Lung Cancer 2011. http://dx.doi.org/10.1016/j.lungcan.2011.07.004

[17] Park SK, Cho LY, Yang JJ, *et al.* Lung cancer risk and cigarette smoking, lung tuberculosis according to histologic type and gender in a population based case-control study. Lung Cancer 2010; 68: 20-26. http://dx.doi.org/10.1016/j.lungcan.2009.05.017

[18] Liu J, Yu Y, Liu L. Biomedical Engineering on a Mobile: Principle and Applications, Beijing: Science Press 2011.

[19] Abroms LC, Padmanabhan N, Thaweethai L, Phillips T. iPhone Apps for smoking cessation a content analysis. Am J Preven Med 2011; 40: 279-85. http://dx.doi.org/10.1016/j.amepre.2010.10.032

[20] Ahern K. Challenges and opportunities of eHealth research. Am J Preven Med 2007; 32(5S): S75-S82. http://dx.doi.org/10.1016/j.amepre.2007.01.016

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