# The Most Cost-Effective Screening Method for Chronic Obstructive Pulmonary Disease among the Bangkok Elderly†

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## Abstract

Our previous studies demonstrated the high prevalence and incidence of Chronic Obstructive Pulmonary Disease (COPD) among the Bangkok elderly, as well as the cost-effectiveness of a questionnaire, chest radiography, and mini peak expiratory flow rate (miniPEF) as screening tools. This final study aimed to identify the most cost-effective screening method among individual, serial and parallel combinations of the above tools, based on the guidelines for diagnosing COPD of the Thoracic Society of Thailand. There were 3,094 elderly aged 60 years and over in 124 urban communities around Siriraj Hospital who participated and completed all the tests.

The results showed that the most cost-effective screening method was the miniPEF at cut-off percentage of 62 per cent of predicted value. This needed to screen 19 elderly people at a cost of 923 baht to detect one case of COPD, with a false negative rate of 1.9 per cent (95%CI 1.3-2.5), a false positive rate of 17.5 per cent (95%CI 15.4-19.6). The questionnaire is the alternative choice of screening tool.

Key word : COPD, Elderly, Cost-effective, Screening

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It is well recognized that Chronic Obstructive Pulmonary Disease (COPD) is a growing major health problem which affects the whole country socioeconomically. The reported prevalence and incidence of COPD[1] in the elderly confirms this immense impact in the near future. The cost-effectiveness of various screening tools i.e. questionnaires[2], chest radiography(CXR)[3], and mini peak expiratory flow rate (miniPEF)[4] have been previously identified.

This study is the final part of the 11th project out of 16 projects under the Integrated Health Research Program for the Elderly of Faculty of Medicine Siriraj Hospital and aimed to identify the most appropiate screening pattern from the above three screening tools using the cost decision tree method.

## MATERIAL AND METHOD

This study was approved by the Ethics Committee on Human Rights involving Human Research of the Faculty of Medicine Siriraj Hospital. The inclusion criteria were all 3,123 elderly people aged 60 years and over in 124 urban communities within a radius of 10 km around Siriraj Hospital in January 1998 who were ambulatory and agreed to participate throughout the study and who could complete questionnaires, miniPEF, spirometry and CXR. The exclusion criterion was the presence of upper respiratory tract infection on the day of study.

The gold standard method for diagnosing COPD was according to the guidelines[5] of Thoracic Society of Thailand i.e. an $FEV_{1.0}$/FVC ratio < 70 per cent with a reversibility of < 15 per cent postbronchodilator (2 puffs of salbutamol by metered dose inhaler using a spacer device) in the absence of parenchymal lesions and cardiomegaly on the CXR.

The questionnaires[2], CXR[3] and miniPEF [4] screening tools were analyzed based on cost decision tree (Diagram 1) consisting of 19 screening patterns for comparison, i.e.

First group : three patterns from three single tools with six results on a decision tree.

Second group : nine patterns from two-tool combinations in both parallel and serial sequences with 12 results on a decision tree.

Third group : seven patterns from three-tool combinations in both parallel and serial sequences with 8 results on a decision tree.

Each decision tree was calculated in terms of probability, outcome, path probability and cost (baht) of each arm.

## RESULTS

Data from 3,094 (99.1% of total) subjects who completed the questionnaire, spirometry and CXR tests were analysed. The characteristics of 3,094 elderly people(Table 1) showed that the COPD cases were older, predominantly males and tobacco smokers with a higher number of pack-year than the non-COPD group.

The outcomes of the response of various tools at each diagnostic Z score are shown in Table 2. The largest number of subjects had negative questionnaires and miniPEF whereas the smallest number of subjects had negative questionnaire and a positive miniPEF.

Examples of cost decision tree calculation are shown in Diagrams 2-4. The calculation of probability was based on data in Table 2. The cost decision tree for a questionnaire costs 92.1 baht (Diagram 2), the miniPEF costs 47.9 baht (Diagram 3), the questionnaire and chest radiography in parallel combination costs 189 baht (Diagram 4).

The cost-effectiveness of 19 patterns are shown in Table 3. The costs of 19 various screening patterns to detect one COPD varied from 923 baht in the first group to 8,790 baht which is the maximum of the third group and also among all patterns. The decision concerning the most appropriate screening method was based on the lowest final cost.

From Table 3 the cost to detect one case of COPD from the first group using a single screening tool followed by gold standard showed that the mini PEF was the lowest (923 baht) compared with CXR (2,008 baht) and questionnaire (1,538 baht). The false positive rate was half of all, while the false negative rate was about the same. Furthermore the number of cases screened in order to detect one case of COPD was similar.

## DISCUSSION

The evaluation of the most appropriate screening pattern among both parallel and serial combination patterns in terms of efficacy and efficiency included three screening tools for diagnosing COPD in the elderly. The most cost effective screening with acceptable false positive and false negative rates was the measurement of miniPEF *via* a mini Wright peak flow meter using diagnostic criteria of less than 62 per cent or 60 per cent (as round number) of predicted value (predicted value of Gregg and Nunn[6]) which should
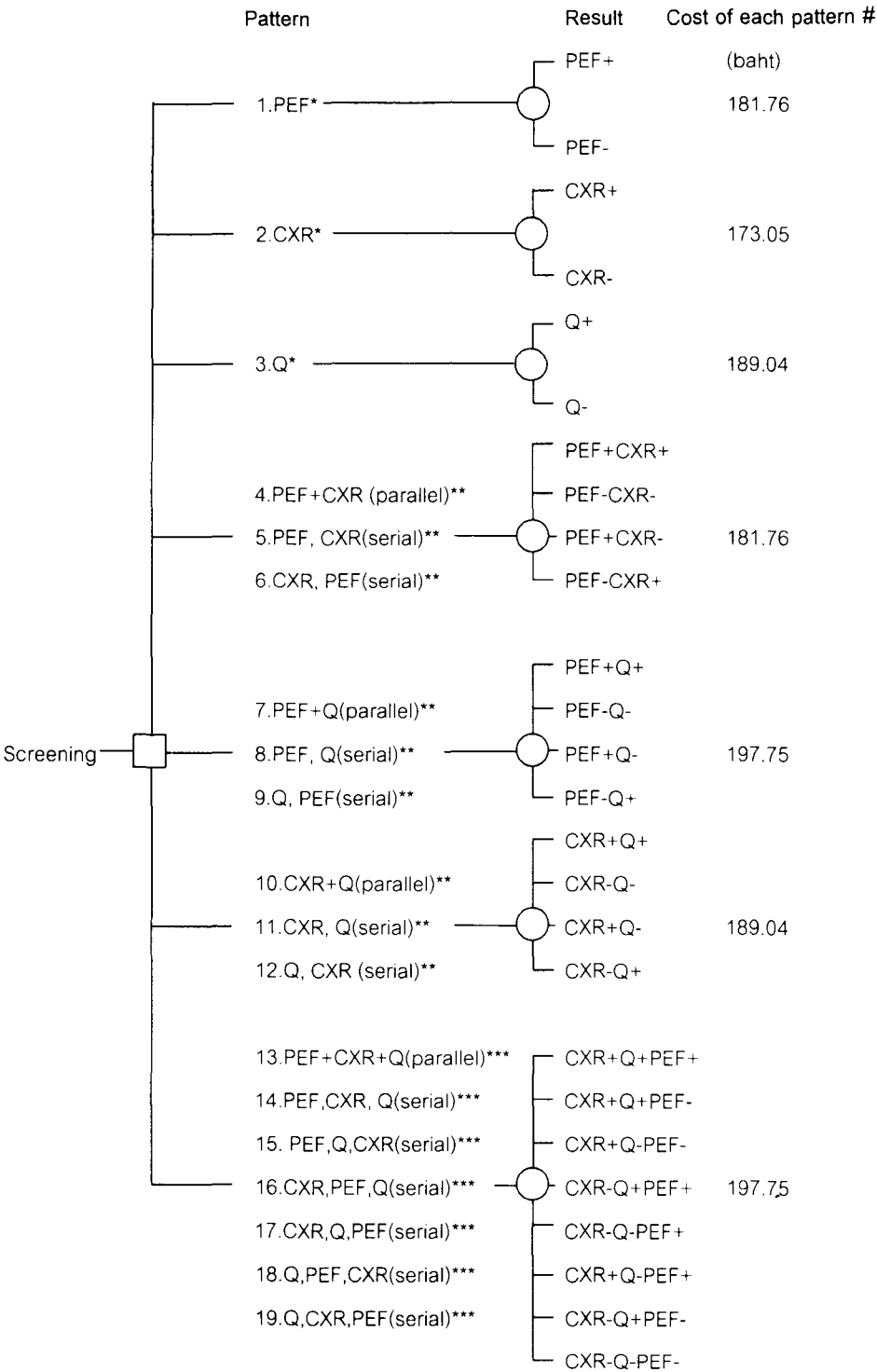
|  Pattern | Result | Cost of each pattern # |
| --- | --- | --- |

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                                              ┌─ PEF+          (baht)
              ┌──── 1.PEF* ─────────────○                      181.76
              │                               └─ PEF-

                                              ┌─ CXR+
              ├──── 2.CXR* ─────────────○                      173.05
              │                               └─ CXR-

                                              ┌─ Q+
              ├──── 3.Q* ──────────────○                       189.04
              │                               └─ Q-

                                              ┌─ PEF+CXR+
                   4.PEF+CXR (parallel)**      ├─ PEF-CXR-
              ├──── 5.PEF, CXR(serial)** ───○  ├─ PEF+CXR-     181.76
                   6.CXR, PEF(serial)**        └─ PEF-CXR+

                                              ┌─ PEF+Q+
                   7.PEF+Q(parallel)**         ├─ PEF-Q-
  Screening ─□──── 8.PEF, Q(serial)** ─────○   ├─ PEF+Q-      197.75
                   9.Q, PEF(serial)**          └─ PEF-Q+

                                              ┌─ CXR+Q+
                   10.CXR+Q(parallel)**        ├─ CXR-Q-
              ├──── 11.CXR, Q(serial)** ────○  ├─ CXR+Q-      189.04
                   12.Q, CXR (serial)**        └─ CXR-Q+

                   13.PEF+CXR+Q(parallel)***  ┌─ CXR+Q+PEF+
                   14.PEF,CXR, Q(serial)***    ├─ CXR+Q+PEF-
                   15. PEF,Q,CXR(serial)***    ├─ CXR+Q-PEF-
              └──── 16.CXR,PEF,Q(serial)*** ─○ ├─ CXR-Q+PEF+   197.75
                   17.CXR,Q,PEF(serial)***    ├─ CXR-Q-PEF+
                   18.Q,PEF,CXR(serial)***     ├─ CXR+Q-PEF+
                   19.Q,CXR,PEF(serial)***     ├─ CXR-Q+PEF-
                                              └─ CXR-Q-PEF-
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**Diagram 1.**    **Decision tree of screening patterns for COPD and their ideal costs.**

\* **First group, \*\* Second group, \*\*\* Third group**
\# **Cost of CXR 80.65 baht, miniPEF 8.71 baht, Questionnaire 15.99 baht, Spirometry 92.40 baht.**

**Table 1.   Characteristics of COPD and non-COPD subjects.**

|  | Population | COPD | Non-COPD | P-value* |
|---|---|---|---|---|
| Number (cases) | 3,094 | 220 | 2,874 | |
| Age, mean ± SD (years) | 67.9 ± 6.4 | 70.2 ± 6.7 | 67.7 ± 6.3 | < 0.001 |
| Sex (male : female) | 0.6 : 1 | 2.6 : 1 | 0.6 : 1 | < 0.002 |
| Smoker (%) | 1,134 (36.6) | 166 (75.5) | 968 (33.7) | < 0.002 |
| Pack-year, mean ± SD | 25.8 ± 24.4 | 32.8 ± 26.4 | 24.7 ± 23.8 | < 0.001 |
| Previous smoker (%) | 449 (14.5) | 64 (29.1) | 385 (13.4) | < 0.002 |
| Current smoker (%) | 685 (22.1) | 102 (46.4) | 583 (20.3) | < 0.002 |
| Non-smoker (%)** | 1,959 (63.3) | 54 (24.5) | 1,905 (66.3) | < 0.002 |

*COPD vs non-COPD, ** Tobacco smoking ≤ 0.5 pack-year.

**Table 2.   Number of cases'responses related to the three screening tools.**

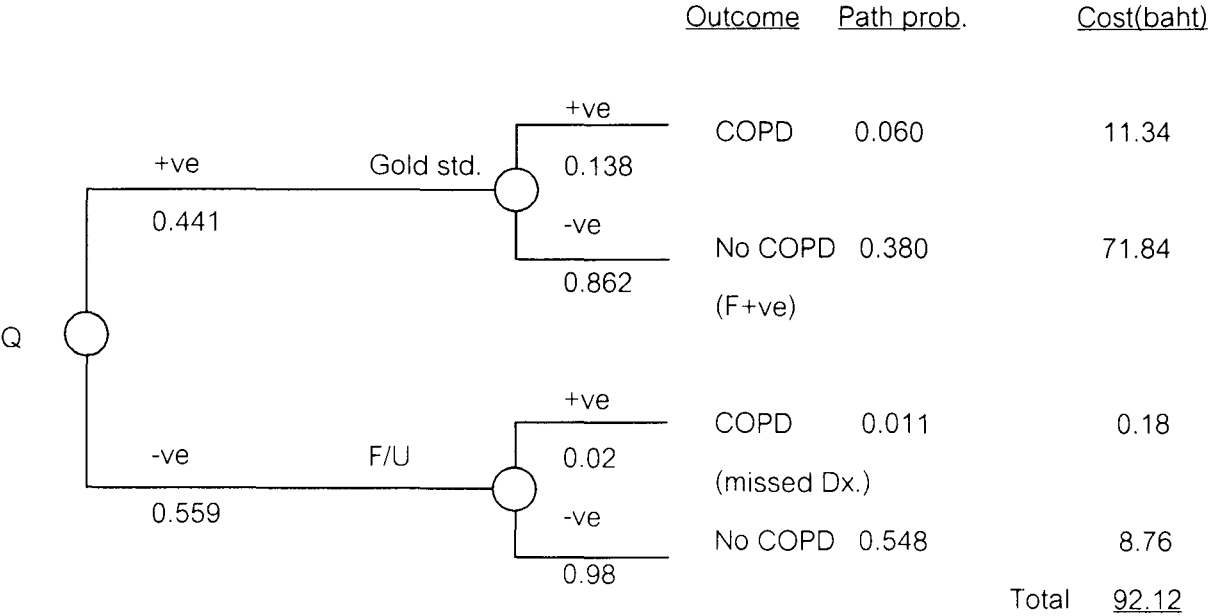|  | MiniPEF+ | MiniPEF- | Q+ | Q- |
|---|---|---|---|---|
| Q- | 269 | 1,461 | - | - |
| Q+ | 433 | 931 | - | - |
| CXR- | 322 | 1,445 | 654 | 1,113 |
| CXR+ | 380 | 947 | 710 | 617 |



Diagram 2.   Cost decision tree for questionnaire (first group).

be appropriate for the elderly of urban community of Bangkok. This method needed to screen 19 subjects in order to detect one case of COPD with a false nega-

tive rate of 1.9 per cent (95% CI 1.3-2.5), false positive rate of 17.5 per cent (95% CI 15.4-19.6) and at a cost of 923 baht. The screening method recom-
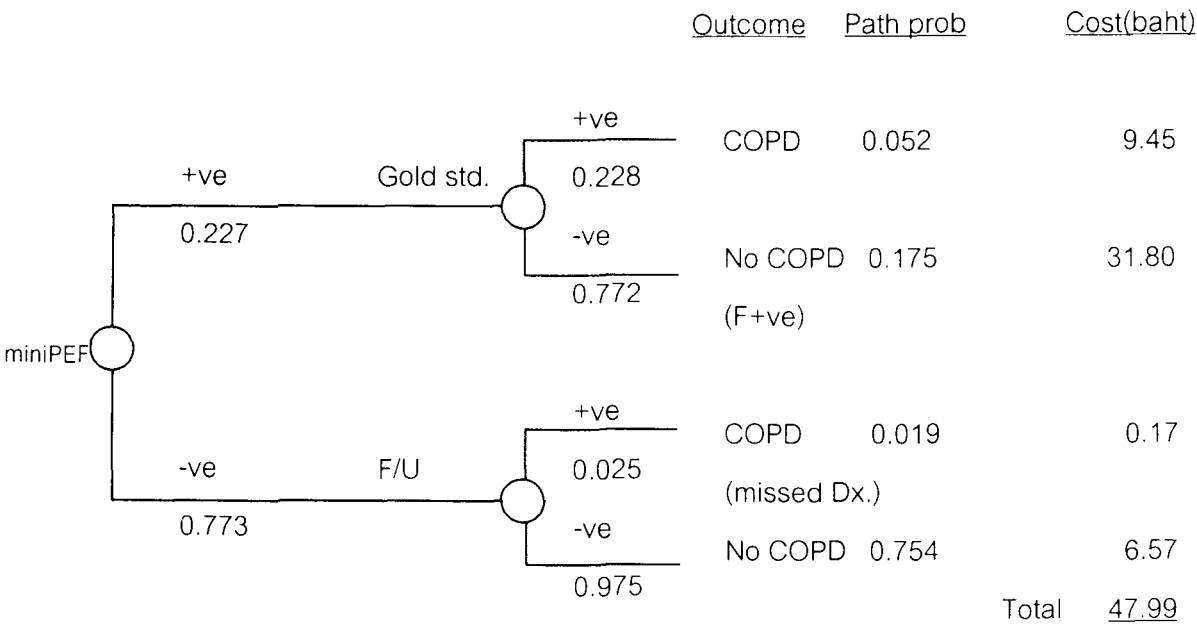
Diagram 3.    Cost decision tree for miniPEF (first group).

Table 3.    Results of various patterns of screening tools for diagnosing COPD.

| Pattern | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | 0.052 | 1.9 | 17.5 | 19.2 | 47.99 | 923 |
| 2 | 0.060 | 1.1 | 36.9 | 16.7 | 120.29 | 2,008 |
| 3 | 0.060 | 1.2 | 38.0 | 16.7 | 92.12 | 1,538 |
| 4 | 0.070 | 0.2 | 46.4 | 14.3 | 132.68 | 1,897 |
| 5 | 0.043 | 2.8 | 8.0 | 23.3 | 47.99 | 1,116 |
| 6 | 0.043 | 2.8 | 7.9 | 23.3 | 123.84 | 2,880 |
| 7 | 0.051 | 0.2 | 57.1 | 19.6 | 189.04 | 3,707 |
| 8 | 0.051 | 2.1 | 17.8 | 19.6 | 92.30 | 1,810 |
| 9 | 0.043 | 2.7 | 9.7 | 23.3 | 51.62 | 1,200 |
| 10 | 0.139 | 16.1 | 38.9 | 7.2 | 197.75 | 1,423 |
| 11 | 0.051 | 2.0 | 17.8 | 19.6 | 127.15 | 2,492 |
| 12 | 0.043 | 2.8 | 9.7 | 23.3 | 96.15 | 2,236 |
| 13 | 0.036 | 2.8 | 9.6 | 27.8 | 197.75 | 5,493 |
| 14 | 0.036 | 2.8 | 8.0 | 27.8 | 316.20 | 8,790 |
| 15 | 0.070 | 31.1 | 61.9 | 14.3 | 295.80 | 4,230 |
| 16 | 0.036 | 3.4 | 8.0 | 27.8 | 198.74 | 5,521 |
| 17 | 0.036 | 2.7 | 9.6 | 27.8 | 197.15 | 5,481 |
| 18 | 0.036 | 2.5 | 6.1 | 27.8 | 196.26 | 5,456 |
| 19 | 0.036 | 2.0 | 6.1 | 27.8 | 197.55 | 5,488 |

A = case detected per one subject screened (case).
B = missed diagnosis (%) = false negatives.
C = false positives (%).
D = number of subjects screened to detect one case of COPD (case).
E = cost for screening one subject (baht).
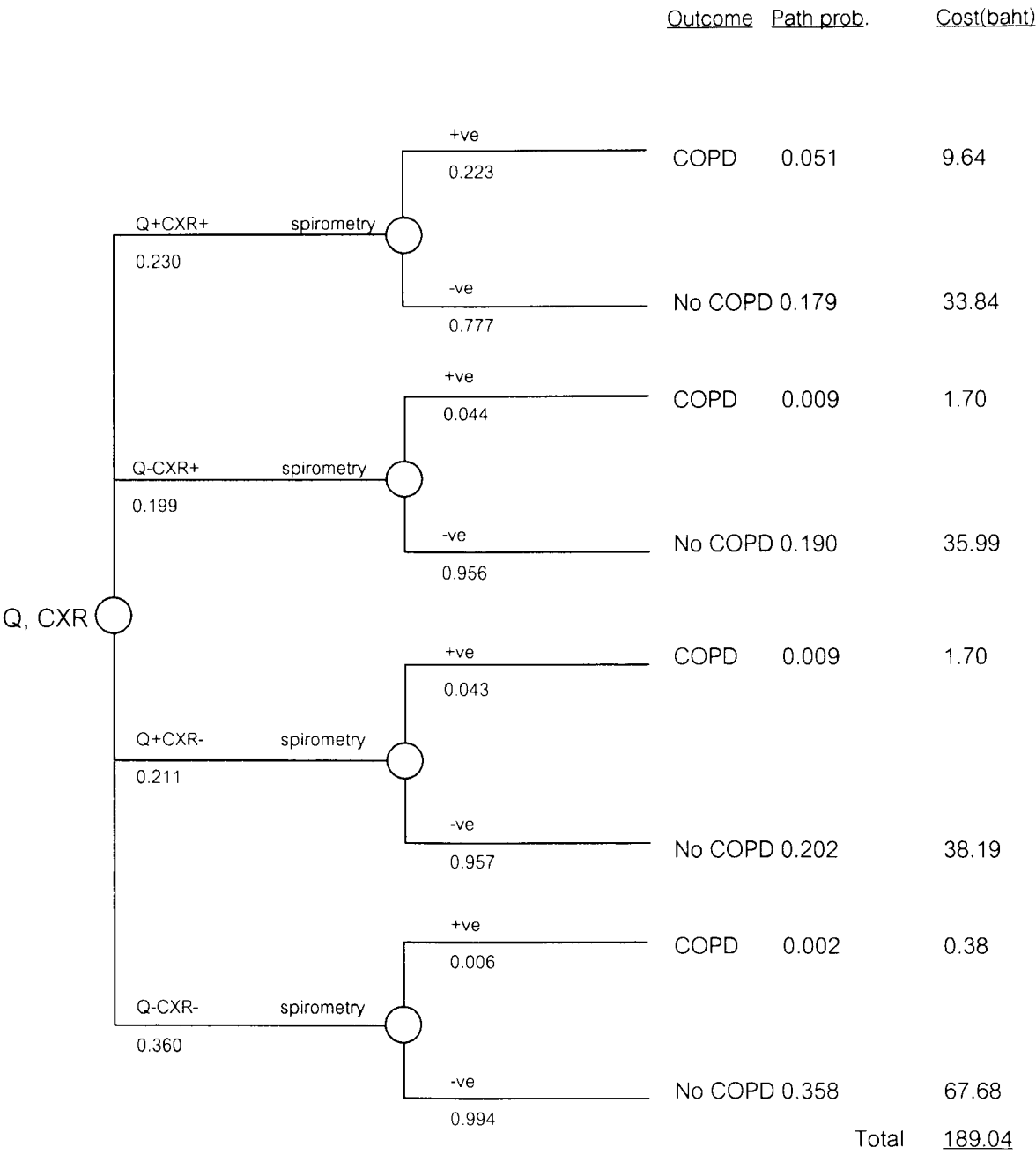F = cost to detect one case of COPD (baht).

| | Outcome | Path prob. | Cost(baht) |
|---|---|---|---|

Q+CXR+  spirometry
0.230

+ve
0.223  → COPD  0.051  9.64

-ve
0.777  → No COPD 0.179  33.84

Q-CXR+  spirometry
0.199

+ve
0.044  → COPD  0.009  1.70

-ve
0.956  → No COPD 0.190  35.99

Q, CXR

Q+CXR-  spirometry
0.211

+ve
0.043  → COPD  0.009  1.70

-ve
0.957  → No COPD 0.202  38.19

Q-CXR-  spirometry
0.360

+ve
0.006  → COPD  0.002  0.38

-ve
0.994  → No COPD 0.358  67.68

Total  189.04

**Diagram 4.  Cost decision tree for questionnaire and CXR in a parallel combination.**

mended, where the mini Wright peak flow meter is not available, should be by Questionnaire which needs to screen 17 subjects in order to detect one case of COPD with a false negative rate of 1.2 per cent (95% CI 0.7-1.7), false positive rate of 38 per cent (95% CI

35.3-40.7) at a cost of 1,538 baht. However, we used our technicians to supervise the questionnaire, and this high cost can be lowered by using generally acceptable trained volunteers whose salary would be around 4,700 baht, which reduce the cost of 14.32 baht (with-
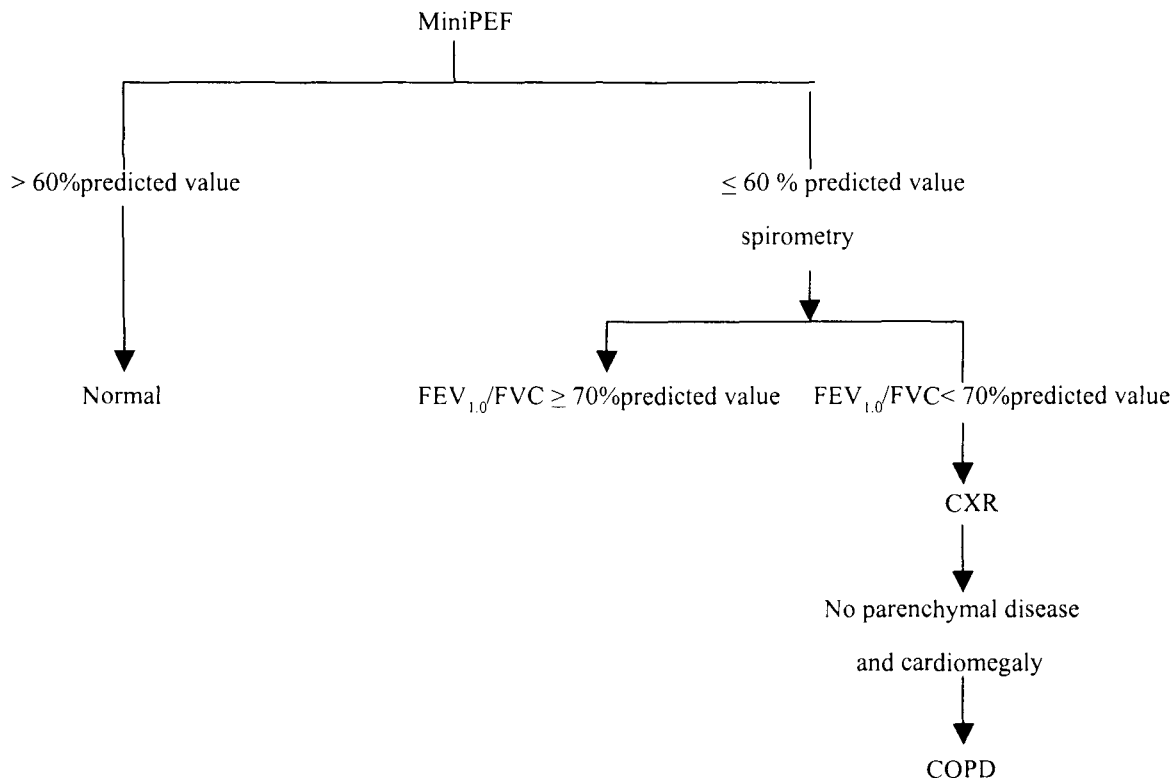
MiniPEF

> 60%predicted value                                    $\leq$ 60 % predicted value

                                                              spirometry

Normal          FEV$_{1.0}$/FVC $\geq$ 70%predicted value    FEV$_{1.0}$/FVC< 70%predicted value

                                                                              CXR

                                                              No parenchymal disease

                                                              and cardiomegaly

                                                                              COPD

**Diagram 5.    Recommendation for COPD screening in the elderly.**

out transportation services) to only 7 baht. Furthermore, if the self assessment using a simplified questionnaire[2] for the elderly is applied, this might have a greater cost-benefit and produce a very simple screening program. Van den Boom G et al (1998)[7] screened the Dutch population aged between 25-70 years old based on FEV$_{1.0}$ and/or symptoms and/or response to bronchodilater and found that the cost to detect one case of COPD was US$ 500-1,000 which was very high compared to our method. Therefore, the selection of the appropriate screening method for the diagnosis of COPD in community needs to be decided using the real details of cost for each part of the process in decision tree.

If this prototype mini peak flow measurement needs 48 baht per subject is applied to the 5.3 million elderly people of 60 years and older nationwide, the cost of screening would be 255 million baht and would save up to 1,180 million baht in treatment costs by influenza vaccination for all detected cases

of COPD regardless of the benefits of the other prevention methods such as stopping smoking [8] and the effect on the quality of life and symptom relief by an inhaled steroid program[9-11]. Therefore, the algorithm shown in Diagram 5 is recommended.

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## REFERENCES

1.   Maranetra N, Chuaychoo B, Dejsomritrutai W, et al. The prevalence and incidence of COPD among urban older persons of Bangkok Metropolis. J Med Assoc Thai 2002; 85: 1147-55.

2.   Maranetra N, Chuaychoo B, Lertakyamanee J, et al. The cost-effectiveness of a questionnaire as a screening test for COPD among the Bangkok elderly. J Med Assoc Thai (In press).

3.   Chuaychoo B, Maranetra N, Lertakyamanee J, et al. The cost-effectiveness of chest radiography as a screening test for COPD among the Bangkok elderly. J Med Assoc Thai (In press).

4.   Maranetra N, Chuaychoo B, Naruman C, et al. The cost-effectiveness of mini peak expiratory flow rate as a screening test for COPD among the Bangkok elderly. J Med Assoc Thai (In press).

5.   Guidelines for diagnosis and treatment of COPD in Thailand. Bangkok; The Thoracic Society of Thailand 1996: 1-28.

6.   Gregg I. Towards a better understanding of chronic bronchitis and asthma. Proc R Soc Med 1965; 58: 232-4.

7.   Van den Boom G, Van Schayck CP, Rutten van-Molken MPMH, et al. Active detection of chronic obstructive pulmonary disease and asthma in the general population. Am J Respir Crit Care Med 1998; 158: 1730-8.

8.   Anthonisen NR, Connett JE, Kiley JP, et al. Effects of smoking intervention and the use of an inhaled anticholinergic bronchodilator on the rate of decline of FEV1. JAMA 1994; 272: 1497-505.

9.   Burge PS, Calverly P. Inhaled steroids in obstructive lung disease in Europe : The ISOLDE trial; protocal and progress [abstract]. Am J Respir Crit Care Med 1994; 149 (Suppl): A312.

10.   Dompeling E, Van Schayck CP, Van Grunsven PM, et al. Slowing the deterioration of asthma an prospective study. Ann Intern Med 1993; 118: 770-8.

11.   Paggiaro PL, Dahle R, Bakran I, et al. Multicentre randomized placebo controlled trial of inhaled Fluticasone Proprionate in patients with COPD. Lancet 1998; 351: 773-80.

# วิธีที่คุ้มค่าที่สุดในการตรวจคัดกรองผู้ป่วยโรคปอดอุดกั้นเรื้อรังในผู้สูงอายุของชุมชนกรุงเทพ ฯ†

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ทำการศึกษาผู้สูงอายุตั้งแต่ 60 ปีขึ้นไปใน 124 ชุมชน รอบโรงพยาบาลศิริราช เพื่อหาวิธีการตรวจคัดกรองโรคปอด-อุดกั้นเรื้อรังที่มีประสิทธิผลที่สุด มีผู้สูงอายุในโครงการ 3,094 ราย ที่รับการตรวจครบทั้งแบบสอบถาม miniPEF ภาพถ่ายรังสีทรวงอกและ spirometry ผลการศึกษาพบว่า วิธีการตรวจคัดกรองที่มีประสิทธิผลมากที่สุดคือวิธีตรวจหา miniPEF ด้วย mini Wright peak flow meter โดยพบว่าค่าเท่ากับหรือน้อยกว่า 60% ของค่าปกติให้สงสัยเป็นโรคปอดอุดกั้นเรื้อรัง วิธีนี้มีผลลบเท็จ 1.9% (95%CI 1.3–2.5) ผลบวกเท็จ 17.5% (95% CI 15.4–19.6) เสียค่าใช้จ่ายเพื่อตรวจค้นโรคปอดอุดกั้นเรื้อรัง 1 ราย เป็นเงิน 923 บาท ต่อการตรวจกรองผู้สูงอายุ 19 ราย ในที่ที่ไม่มีเครื่องมือชนิดนี้ การตรวจคัดกรองโดยใช้แบบสอบถามเป็นทางเลือกอีกทางหนึ่งที่เหมาะสม

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