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Developing a web application to provide information on common work-related asthma causative agents

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Abstract

Occupational asthma (OA) is one of the most common occupational lung diseases. There are currently about 300 documented asthmagens. Patients have a chance to be cured if the OA is handled correctly. Diagnostic delay is often due to the attending not taking the occupational history. The aim of our study was to develop a web application that would deliver fast and accurate information. Methodology: The three phases of web application development were included. Sourcing input data from a systematic review of 1,403 studies found when searching for review and systematic review and full text and inclusion criteria. A total of 276 eligible studies were selected, and after reviewing abstract, 25 were fully reviewed and summarized into 2 groups-14 high molecular weight agents and 14 low molecular weight agents. The industrial code was then reviewed, and prototypes developed. Evaluation of prototypes for System Usability Scale (SUS) by experts was performed. The expert suggestions were reviewed and revised to create a second prototype. Trialing web application for use by primary care physicians. The final web application was evaluated by primary care physicians was implemented. The median of SUS was 75, which is greater than the average. In future, we seek to develop tools for analyzing the probability of diagnosing OA, which would help making diagnosis more convenient. The earlier diagnosis can be achieved, the better the prognosis.

Keywords: Work-related asthma, Occupational asthma, Allergens, Immunologic sensitization, Medical informatics applications

1. Introduction

Asthma is a major worldwide health concern, with 10-15 percent of asthma occurring in adulthood [1]. More than 90 percent of workplace asthma causative agents are immune-stimulated or sensitizer-induced [2]. Generally, after exposure to asthmagens, the time to develop disease varies. For example, people working in laboratories with animals may develop rhinoconjunctivitis within 1-2 years and respiratory symptoms in 2-3 years [3].

Some research has investigated the timing to refer patients to a chest physician for diagnosis of occupational asthma. Fishwick et al. found that it took an average four years to develop disease from the first visit to a primary care center to evaluation at a secondary care center [4]. Poonai et al. found that the delay in diagnosis of occupational asthma was due to several factors [5]. The most common reason was that primary physicians do not investigate the potential link between occupation and symptoms. Another major reason was worker fear of losing work, so workers obfuscate, and primary care physicians remain unaware of occupational asthma [5]. Some studies found that doctors have incomplete occupational history medical records. Manotham et al. [6] reported

that only 24.8% of occupational history was recorded in patient medical records, and 45.7% of occupation history was recorded by doctors. The fastest referral to a specialist physician has been discussed in recommendations from both the British Thoracic Society [7] and the Canadian Thoracic Society [2].

Nowadays, the use of medical technology is more popular and accepted. Mobile medical applications, or mHealth, are defined by the Global Observatory for eHealth (GOe) [8] as medical and public health that is supported by mobile operating systems. mHealth can be categorized by purpose, such as treatment monitoring, the appointment reminders, and electronic medical record-keeping. Information providing and decision-making systems are included [8].

Diagnosis of occupational asthma is essential to the prognosis of occupational asthma; therefore, taking a history is crucial. There are, however, as many as 300 common asthmagens. [9], and this is likely to increase. So, a tool is needed to assist doctors in collecting reliable information and deciphering it for faster diagnosis and treatment. Additionally, when occupational asthma is diagnosed, the patient could aim to reduce or stop exposure to suspected asthmagens [10]. This research objective is 1. To develop a web application for physicians to provide industry and common asthmagens information and 2. To test the usability of such a web application.

2. Materials and methods

This research set out to develop web applications. The research design is research and development. The goal was to help primary physicians determine a patient's primary asthmagens so as to increase the chances of occupational asthma diagnosis. There were three phases of web application development:

2.1 Development of input data from systematic literature reviews

Information on occupational asthmagens is increasing. There are different types of research that provide information, for example, case reports, epidemiological studies, and review articles. A systematic review of the literature was been done to create a reliable dataset. We searched systematically for the period 1990-2020 in the Medline (PubMed, 1990 to August 2020, accessed 01 October 2020). We used the following search terms to search databases PubMed and Thai journal online: causative agents for occupational asthma; work-related asthma; causative agents for work-related asthma; causative agents for occupational asthma; common asthmagens. The inclusion criteria were that the journal had to have an impact factor of 5 or greater.

2.2 Development of prototypes and evaluated by experts

After the systematic review, the most common occupational asthma causative agent was obtained. The we searched for occupations and workplaces where such asthmagens are likely to be found. Suspected workplaces or occupations which have common asthmagens was searched in the Occupational Health Haz-Map® database and the Oasys research group, part of the Midland Thoracic Society, UK. We then matched the industries with the International Standard Industrial Classification (ISIC codes). With the assistance of our development team, we designed web application with an alphabetical search and links between asthma causative agents and the ISIC codes.

This web application includes the main page, the information page about the WRA, a search page, and the hospital referral page. On the search page, one finds the occupational asthma screening questions. The literature review revealed that relevant questions should be divided into questions about symptoms of asthma and the relationship between work and respiratory symptoms. Asthma-like symptoms were adapted from the Global Initiative for Asthma (GINA) and work-related questions were reviewed and adapted from the American College of Chest physician and British Thoracic Society guidelines [3,7,11]. Diagnosis guidelines were presented in Table 1 shown information page. The screening questionnaires were presented in Figure 1. In addition to the search pattern design, the researchers determined how to facilitate users by creating a function to export search files.

Table 1 Occupational asthma diagnosis guideline.

American College of Chest physician [1]	British Thoracic Society guideline [7]
-Asthma diagnosed -Symptoms after entering the workplace -Relationship between symptoms of asthma and work -One of the following a) Workplace contains occupational asthmagens b) Change in FEV1 or PEFR associated with work c) Variation of non-specific airways related to that work. d) SIC of suspected agents positive e) Symptoms occur after exposure to workplace irritant	- Asthma diagnosed (new-onset asthma, relapse of childhood asthma) -Ask about relationship between symptoms of asthma and work (better or worse on rest days and holidays) -If there is work-related, investigate a) In primary and secondary health care, additional history, pulmonary function test, and serial PEF required, and if possible, bronchial responsiveness, immunology, OASYS2. b) In tertiary health care, additional history required. Pulmonary function test and serial PEF, bronchial responsiveness, immunology, and OASYS2, SIC should be done for occupational asthma diagnosis.

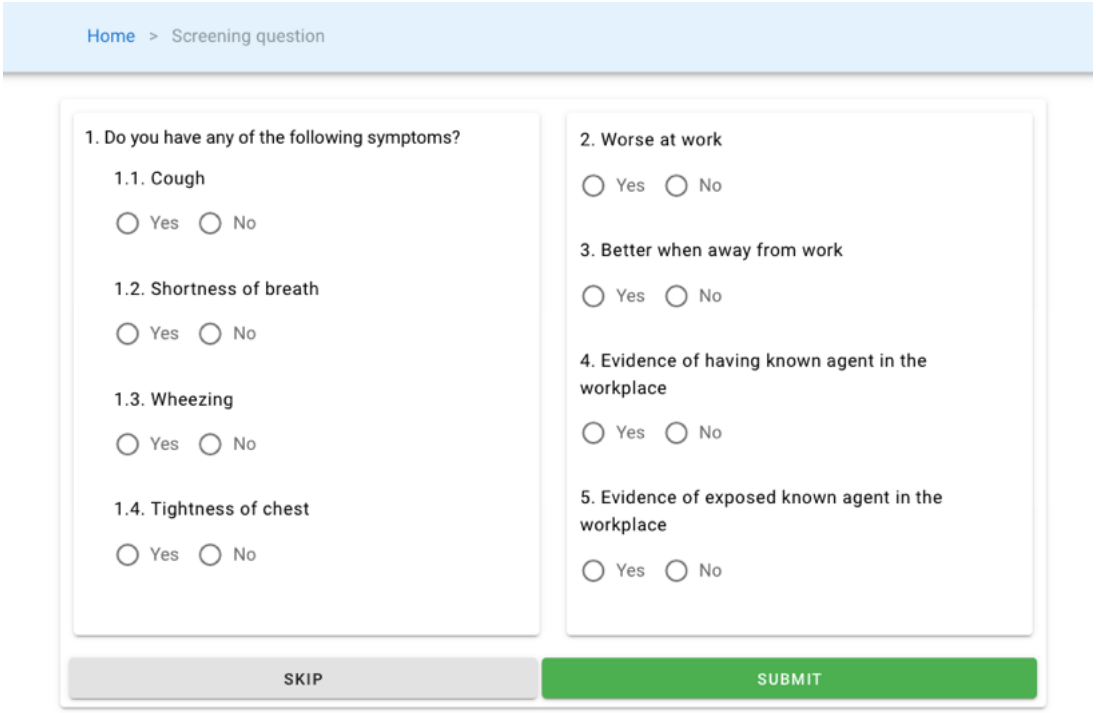


Figure 1 Screening questions for asthma and work-related symptoms

Once the screening question is successfully answered, users are directed to a search page. The answers are recorded and displayed in the summary of the search. Users can search from a list of common occupational asthmagens by searching International Standard Industrial Classification (ISIC codes). Asthmagens and ISIC codes are linked to facilitate opening of the information. Examples of a search page by a list of common asthmagens and ISIC codes are shown in Figures 2 and 3.

The web application development team wrote code for responsive web applications. Six experts in the relevant field evaluated the first prototype. The team included chest physician (n=1), occupational medicine physician (n=1), web application developers (n=2), family medicine physician (n=1), and general physician (n=1). We recorded the SUS and suggestions vis-à-vis web evaluation on web application effectiveness, efficacy, and overall satisfaction adapted from system usability testing (ISO 9241-11) [12]. Web application evaluation and SUS were shown in appendix 1.

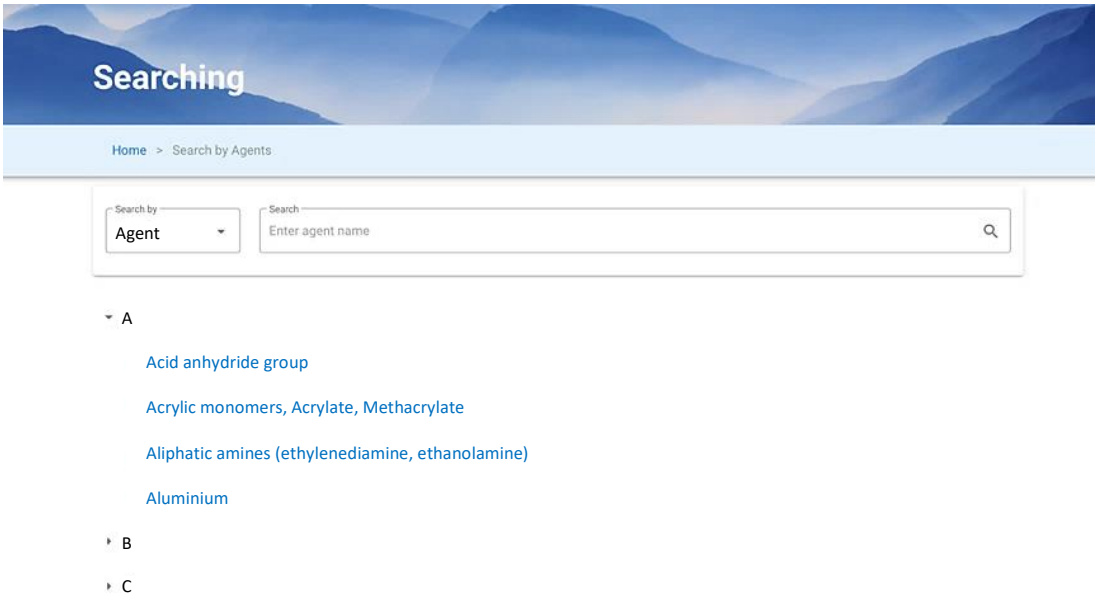
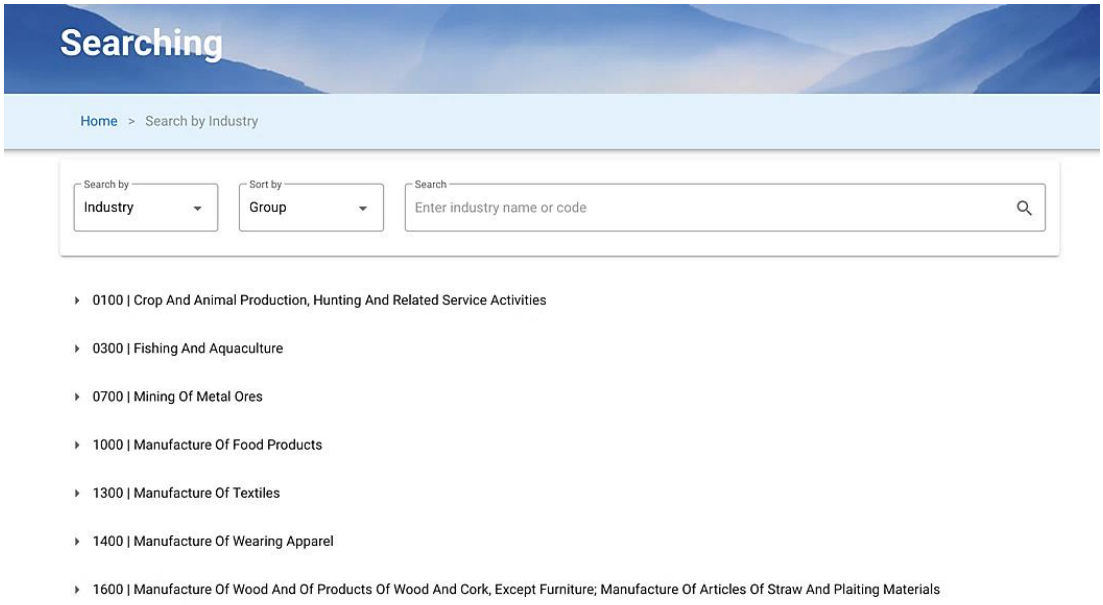


Figure 2 Example of search page by list of common asthmagens



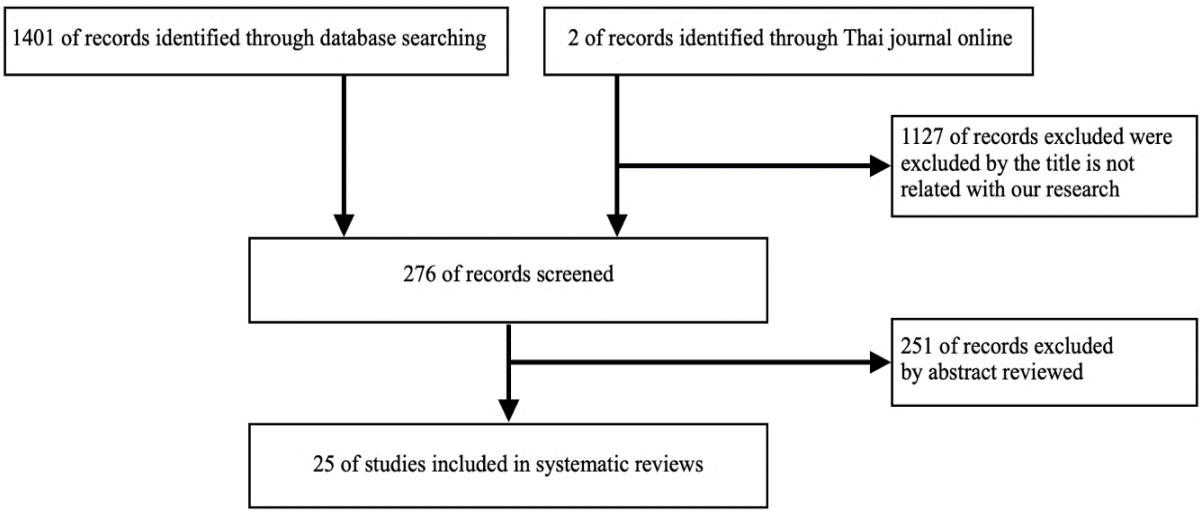
Figures 3 Example of search page by ISIC codes

After creating a prototype web application and improving it based on expert suggestions, it was trialed as a second web application prototype with primary care physicians. The assessments were performed using six primary care physicians, and the same expert assessment test. Afterwards, responsive web applications were done based on expert suggestions and primary care physicians.

3. Results

3.1 Result from systematic review of literature for create the data set

Based on a systematic review of relevant research from 1990-2020 in the Medline (PubMed, 1990 to August 2020, accessed 01 October 2020), 1,403 studies were found. After searching in terms of review and systematic review and full text and inclusion criteria, a total of 276 eligible studies were screened. After reviewing abstract, 25 articles were fully reviewed (Figure 4). The most widely discussed high molecular weight agents were divided into 14 groups: henna, animal protein, natural latex, 14 low molecular weight agents, isocyanate groups, acid anhydrides, and colophony. All causative agents were shown in Table 2.



Figures 4 Result of systematic literature review, following PRISMA guidelines

Table 2 Asthma causative agents obtained from literature review.

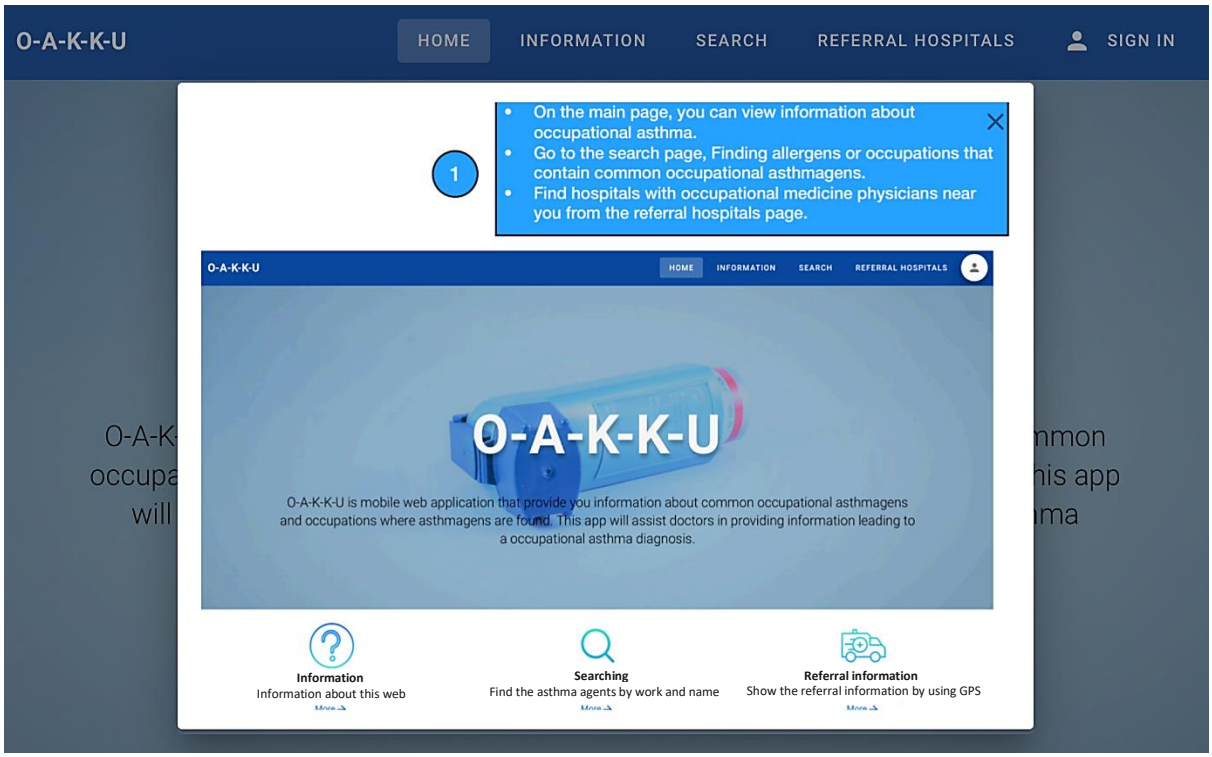
High molecular weight agents	Low molecular weight agents
1. seafood, 2. eggs, 3. castor bean, 4. coffee bean, 5. gum acacia, 6. henna dye, 7. ornamental plants, 8. bird proteins, 9. dairy process and product, 10. flour and wheat, 11. laboratory animal protein, mammalian protein, 12. insect, bee, silkworm, larvae, mite, 13. natural rubber latex, 14. plant	1. acid anhydrides, 2. acrylic monomers, 3. aliphatic amines, 4. aluminum, 5. antibiotic drug, 6. biocide, 7. chromium, 8. cobalt, 9. colophony, 10. isocyanate groups, 11. nickel, 12. persulfate salts, 13. platinum, 14. tropical woods, wood dust

3.2 User interface of "OAKKU"

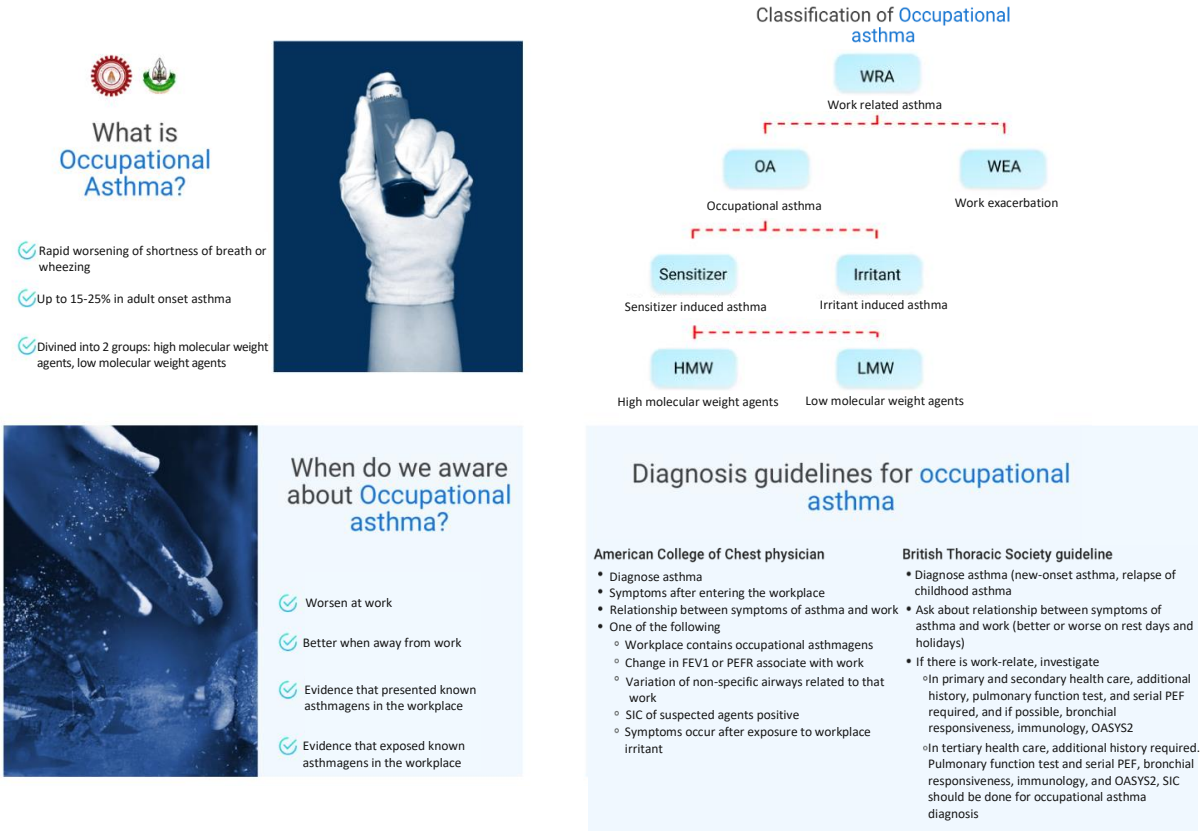
Based on the steps mentioned, the result was the responsive web application "OAKKU." An instruction manual is found on the home page that will pop up as a reminder to allow users to study the usage and recognize the various features of the web application (Figure 5). When visiting an information page, users will find basic information about occupational asthma. The page makes users aware of suspected symptoms of occupational asthma. Types of occupational asthmagens are presented as well as sending an examination to diagnose occupational asthma (Figure 6).

Before going to the search page, users will find screening questions for asthma symptoms and occupational asthma symptoms. The above questions will guide the physician if the patient is suspected of or is compatible with occupational asthma (Figure 1), and answers are saved for export when the search is complete.

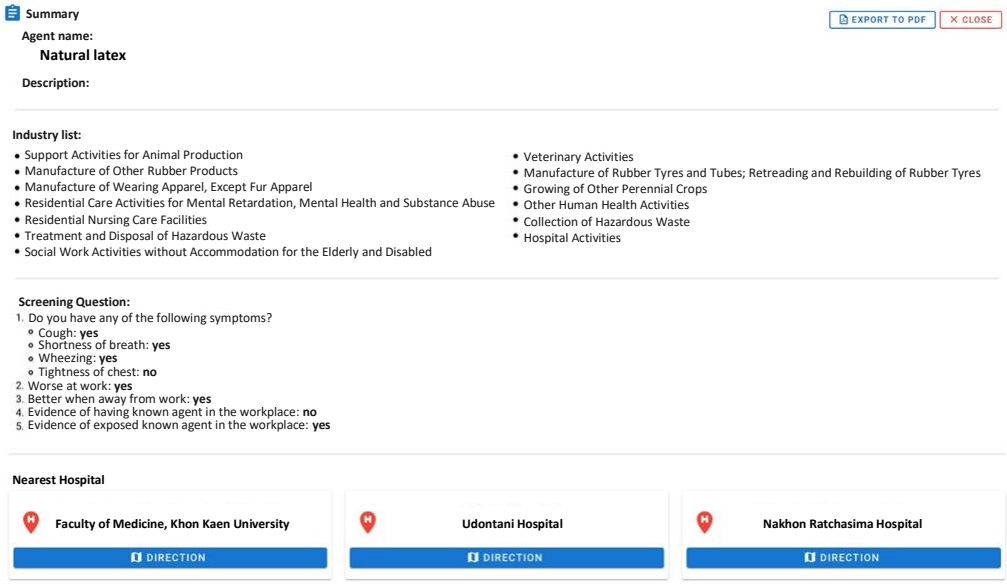
When visiting the search page, users can search for a list of common asthmagens and industry names or ISIC codes, if users cannot identify the suspected asthmagens. When searched successfully, Users can summarize the search data, export it as a PDF file and attach it with other referral documents for the convenience of the referred patient for further diagnosis of occupational asthma. The summary page contains the following: 1. date of searching, 2. name of the suspected asthmagens, 3. names and industry codes based on ISIC codes, 4. selected screening answers, and 5. the three closest hospitals with occupational medicine physicians and their essential contact information. An example of a summary page were shown in Figure 7.



Figures 5 Home page and web application instructions

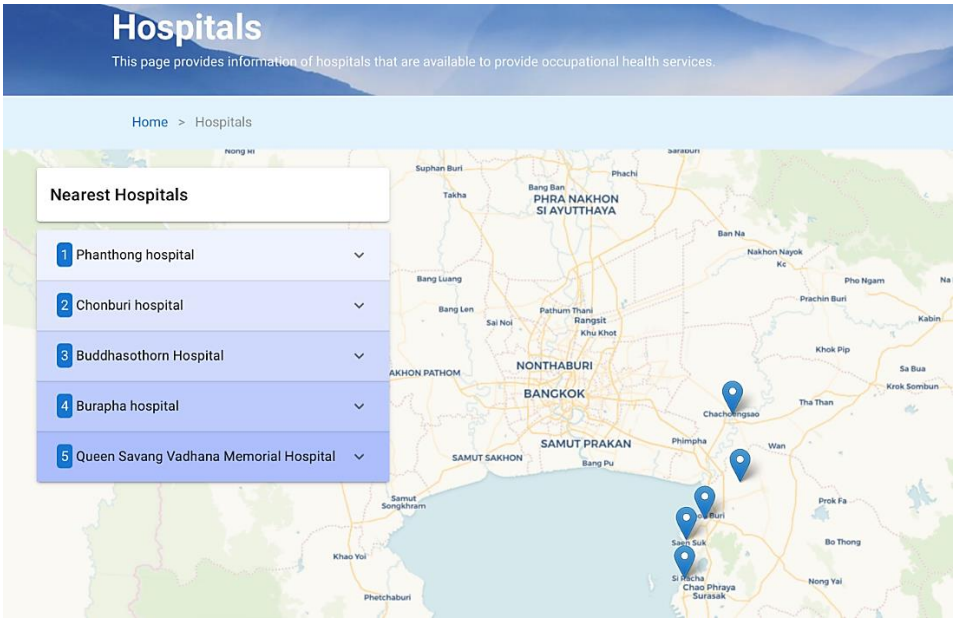


Figures 6 Information page.

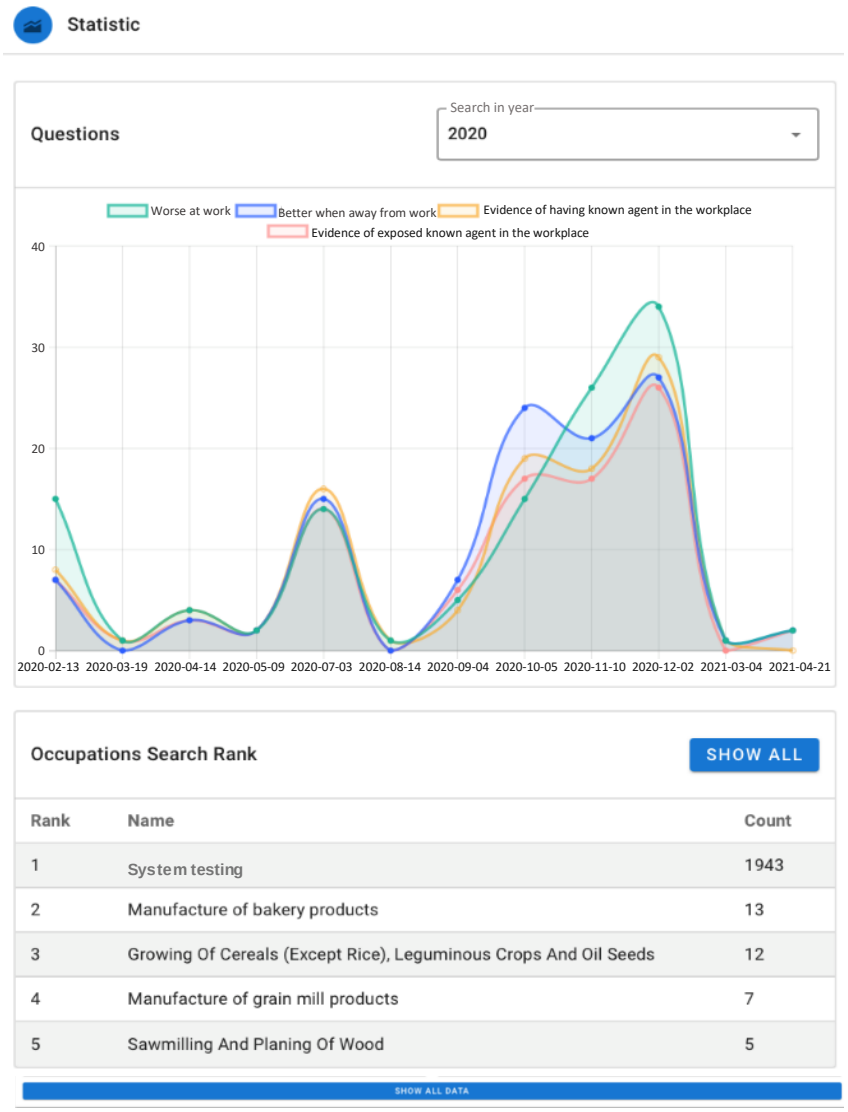


Figures 7 Information on the summary page.

The Referral page (Figure 8) aims to provide hospital referral information for primary care physicians so as to reduce waiting time for referrals, and to manage patient occupational health services. If an occupational asthma diagnosis is done quickly, a patient can eliminate exposure and improve their prognosis. Finally, those who have access codes can view usage data on searched for causative agents or ISIC codes (Figure 9). Such information may be used for policy-making purposes. As asthmagens are found in a specific area where occupational asthma has been diagnosed, the asthmagens may be a health problem in that area. After a successful search, users will receive information for decision-making in the referral and diagnosis of occupational asthma, including 1. suspected symptoms of asthma and occupational asthma, 2. suspected asthmagens, and 3. hospital contact information for early referrals.



Figures 8 Hospital contact information for referral.



Figures 9 Overview of web application usage data.

3.3 Web application evaluation

The results of the first evaluation of the prototype web application had the following recommendations:

1. Web application usage: Several test users suggested using the Thai language as well as English. Another suggestion was about integrity in use by having the ISIC codes detailed on the summary page, removing hospital images to reduce unnecessary processes, and displaying extended instructions.

2. Content: Some test users reported that some agents cannot be searched because the tool prioritizes the common asthmagens. After a second evaluation, it was found that the SUS score improved from 50 to 67.5. Most of the recommendations were in terms of functional integrity, such as color adjustment.

After modifications following the suggestions (except for introducing the Thai language), the web application was tested again using a demonstration patient case. The 2 cases were adapted from a case study in the workplace 4th edition [1]. Primary care physicians were reading the case studies and testing the web application. It was found that the SUS score after the second revisions had an improvement in the SUS score (Table 3). The SUS score of the last web application testing was 75, which was greater than the general average of the assessment, and many users said that the tool was easy to use and useful for improving awareness of occupational asthma.

Table 3 Median, IQR, min-max of SUS of web application assessment

Statistic	SUS of 1st prototype	SUS of 2nd prototype	SUS of web application
No. of users	6	6	20
Median	50	67.5	75
Interquartile range	24.38	28.75	36.88
Min	47.5	60	42.5
Max	77.5	100	95

4. Discussion

4.1 Discussion about the literature systematic review

Review articles were selected on the basis of a credible, reliable summary of the knowledge of the subject [13]. All selected studies contained 28 identical occupational asthmagens as some agents are widely used and cannot be substituted, such as laboratory animal proteins, seafood protein, starch, isocyanate, or cleaning agent such as chloramine-T. There was only one review article in Thailand that compiled information on occupational asthmagens [14]. According to statistics from Surveillance of Work-Related and Occupational Respiratory Disease (SWORD), there are nine groups of asthmagens reported in patients diagnosed with occupational asthma: flour, cleaning products, isocyanates, grains, hair products, glue and adhesives, enzyme amylase, other animal proteins (mites, dogs, horses), and unknown agents [15]. Our input datasets matched 8 in 9 of the SWORD data. The mismatched group was unknown agents. Furthermore, based on statistics from the Industrial Injuries Disablement Benefit (IIDB) in 2010-2019, we matched a group of asthmagens that had 5 of the 7 with our input datasets [15]. Based on this evidence, we concluded that common asthmagens have remained the same from the past to the present.

4.2 Discussion about the results of the web application evaluation

The web application development started in August 2020. It took two months to review the literature and summarize the input data. It took a further 2 months to develop the prototype. After the first user evaluation, suggestions were used to revise and develop the second prototype (1 month). The average SUS is 68. The tool has a SUS above the 50 percentiles of other similar applications. It is generally accepted that if there are only 5 testers, they will be able to identify an average of 85% of problems, while 10 testers can find an average of 95% of the problems, and 20 can identify 98% of the problems [16]. Six content experts participated in the research and web application evaluation process, while 20 doctors joined as test users. Evaluations were divided into two main points: 1. suggestions related to content, and 2. feedback relating to the user experience. Details of the recommendations and solutions were presented in Table 4. However, the researcher considered that the English version of web application can cause the SUS assessment to be slightly low. Because the trial user is a Thai user, that may cause low validity.

This is the first new innovation in the field of occupational medicine in Thailand. So, we suggested that our application should be done with the quality of testing for web applications in asthma clinics and airway disease clinics, and then should be compared between the physicians and non-physicians to evaluate benefits in different group. And the next generation of application is to develop capacity for a bilingual system. In our case, include

Thai and English. Other's suggestion was to show more occupational medicine physicians' information, that would be beneficial to users for referring patients. Importantly, our web application can collect the asthmagens data which can be used for analyzed for further policies prevention.

Table 4 Details of recommendations and solutions.

Suggestion of experts	Discussion
1. Failure to search for information on asthmagens	Searching may be based on user experience. Asthmagens may not be common. Web application should notify if asthmagens not found. If patients have symptoms, further diagnosis is recommended. If patients have asthma-like symptoms, diagnosed and remove patient from suspected asthmagens as soon as possible.
2. Selection of search terms can be difficult, and users need some knowledge of occupational medicine	Search function can be used as asthmagens are internationally named. Industry group searches can be difficult as each industry adapts information from the ISIC. Workers may have been exposed to asthmagens from other tasks in the workplace. Using occupation code may cause false negative screening. Develop system to accept other languages for broader utility.
3. An improved decision-making system is needed to help general practitioners make decisions	Diagnosis of occupational asthma remains under-reported. Main reason is that primary care physicians are unaware of asthmagens. After testing, a web application can be used to improve awareness of occupational asthma. A decision-making system like this helps inexperienced physicians.

5. Limitations

Our study is available only English version because of terms of reference with our development. In addition, this was tested among Thai users that could make the low validity of SUS.

6. Conclusion

Web applications created by the researchers and programmers were able to achieve the research objectives. This web application is provided on possible causative agents and industry information. Other's outcome was raising awareness of occupational asthma diagnosis among primary care physicians. The latter expressed interest in having improved decision-making systems for diagnosis and care of occupational asthma. After widespread usage, our web application can collect the asthmagens data, which can be used for analysis for further prevention policies.

7. Acknowledgements

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8. References

[1] Malo JL, Chan-Yeung M, Bernstein DI. Asthma in the workplace. 4th ed. Boca Raton: CRC Press; 2013.
[2] Tarlo SM, Boulet LP, Cartier A, Cockcroft D, Côtè J, Hargreave FE, et al. Canadian thoracic society guidelines for occupational asthma. Can Respir J. 1998;5(4):289-300.
[3] Cartier A, Grammer L, Malo JL, Lagier F, Ghezzo H, Harris K, et al. Specific serum antibodies against isocyanates: association with occupational asthma. J Allergy Clin Immunol. 1989;84(4 Pt 1):507-514.
[4] Fishwick D, Bradshaw L, Davies J, Henson M, Stenton C, Burge S, et al. Are we failing workers with symptoms suggestive of occupational asthma. Prim Care Respir J. 2007;16(5):304-310.
[5] Poonai N, van Diepen S, Bharatha A, Manduch M, Deklaj T, Tarlo SM. Barriers to diagnosis of occupational asthma in Ontario. Can J Public Health. 2005;96(3):230-233.
[6] Manotham M, Chaiear N, Yimtae K, Thammaroj T. Completeness of occupational history taking record for out-patients with potential work-related disorders at a university hospital in northeast of Thailand. Srinagarind Med J. 2015;33(2):169-175.

[7] Fishwick D, Barber CM, Bradshaw LM, Harris-Roberts J, Francis M, Naylor S, et al. Standards of care for occupational asthma. Thorax. 2008;63(3):240-250.
[8] World Health Organization. mHealth: new horizons for health through mobile technologies. Geneva: WHO; 2011.
[9] Malo JL, Chan-Yeung M. Asthma in the workplace: a Canadian contribution and perspective. Can Respir J. 2007;14(7):407-413.
[10] Taylor AN, Cullinan P, Burge PS, Nicholson P, Boyle C. BOHRF guidelines for occupational asthma [editorial]. Thorax. 2005;60(5):364-366.
[11] Jongkumchok W, Chaiear N, Boonsawat W, Chaisuksant S. Occupations and causative agents among work-related asthma patients in easy asthma clinic, Srinagarind Hospital, Khon Kaen, Thailand. Am J Public Health Res. 2018;6(2):111-116.
[12] Alturki R, Gay V. Usability testing of fitness mobile application : methodology and quantitative. J Comput Sci Inf Tech. 2017:97-114.
[13] Glenn W. Suter II. Review papers are important and worth writing. Environ Toxicol Chem. 2013;32(9): 1929-1930.
[14] Maneechai W, Prabhabpongsa P, Mitrthammasri W, Sangarsop-viriya A. Occupational asthma. RTA Med J. 2016;(4):185-188.
[15] Health and Safety Executive (HSE). Work-related asthma statistics in Great Britain, 2020. London: HSE; 2020.
[16] Faulkner L. Beyond the five-user assumption: benefits of increased sample sizes in usability testing. Behav Res Methods Instrum Comput. 2003;35(3):379-383.