CHLORINE VAPOR EFFECT ON CARDIOPULMMONARY SYSTEM DUE TO INCOMPETENT ARCHITECTURAL DESIGN IN A TROPICAL CLIMATE

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ABSTRACT

This research has purpose to determine cardiovascular and pulmonary effect of chlorine vapor with chest x-ray which compared between each age group. Researcher collected patient data who exposed to chlorine vapor under incompetent architectural design building in tropical area during working in the chlorine storage building compared with non-exposure group. Humidity is not related with vaporization directly. Exclusion criteria are patients who were diagnosed with cardiovascular or pulmonary problem prior starting period. There are statistical significant between controlled and experimental groups about diameter of descending branch of right pulmonary artery compared with age.

Study support hypothesis of change in cardiovascular and respiratory system under environment of incompetency building in a tropical climate but almost of controlled group are rather younger than experimental group which could be the cause of error.

Keywords : Architecture, Chlorine Vapor, Cardiopulmonary, Working, Tropical

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Chapter 1

Introduction

1.1 Introduction to problem

The chlorine was discovered by Carl Wilhelm Scheele in 1774 AD[1] Chlorinated water were widely used in household and industry. The chlorine rate in the upper layers of the soil is about 10ppm.[2] Chlorine has multiple uses as it is used in the purification of drinking water as a disinfectant and is also used in swimming pool, tissue, plastic and solvent industry[3] There are many faces for the use of chlorine in industrial. The exposure is accidental by freeing or draining or ignorance. The most harmful methods of exposure are inhalation of chlorine gas or by direct contact with the skin and the eye or digestion of chlorine-containing food or drinking. The EPA in 2014 has classified chlorine-compounds as the main cause of cancer, especially liver, kidney and colonic cancer. The exposure of chlorine also increases when swimming with chlorinated water as the high temperature of water. The study revealed 30 degree celcius of water increase the proportion of chloroform to 0.2mg, but if it rose to 40 degree celcius, the concentration of up to 7mg, resulting in a lack of blood flow in capillaries.[4] The halation of chlorine vapor during bathing increases the problem of asthma, allergies, cough, sputum and chest pain. Moreover, aircraft turbofans (> 26.7 kN thrust) are currently regulated for their emissions, which include oxides of nitrogen (NOx), unburned hydrocarbons (HC), carbon monoxide (CO), and smoke. The smoke regulation also applies to engines with output ratings < 26.7 kN. Smoke emissions are mainly carbonaceous particles emitted as a product of incomplete combustion, and these particles are now the subject of a proposed new standard that will regulate the number and mass of non-volatile particles (nvPM) which include PM2.5[5]

Knowledge about chlorine was developed over few decades. In animal, The final body weights of the rats measured before euthanasia were extremely close between the EG and the CG (344.34 ± 34.95 g vs. 337.07 ± 46.00 g, $p>0.05$). No significant behavior differences were observed between the two groups during the entire experimental period; however, some unusual appearance changes appeared in the EG rats. First, the skin around their eyes became increasingly red with the development of the experiment, and in the ending period of the experiment, bloodstains could be observed in the rims of most rats' eyes. Second, from the third experimental week on, an increasing number of rats had bloodstains appearing at the tips of their noses; however, approximately two weeks later, this symptom gradually disappeared. Third, their fur became increasingly dry and lackluster, and significant signs of hair loss were observed during the last month.

These results indicated that the fur, respiratory tracts and eyes of the EG rats were severely affected by chlorinated water, although their growth was essentially unaffected. According to our observations, the daily behaviors and sizes of the EG rats were normal, and their final body weights were even slightly heavier than those weights of the control group. Researcher team choose CT ratio to evalute cardiac problem and descending branch of right pulmonary artery to evaluate lung pressure. The cardiothoracic ratio is measured on a PA chest x-ray, and is the ratio of maximal horizontal cardiac diameter to maximal horizontal thoracic diameter (inner edge of ribs/edge of pleura). A normal measurement is 0.42-0.50. A measurement <0.42 is usually deemed to be pathologic.

After long-term observation of the tap water building of community in Ubon Ratchathani Province. We found suspicion circumstance of worker in their workplace. Worker have worked on circumstance which may take risk of chlorine vaporization and chlorine exposure.

Image 1 : Chlorine tank

Source : researcher (2022)

Image 2 : Chlorine tank

Source : researcher (2022)

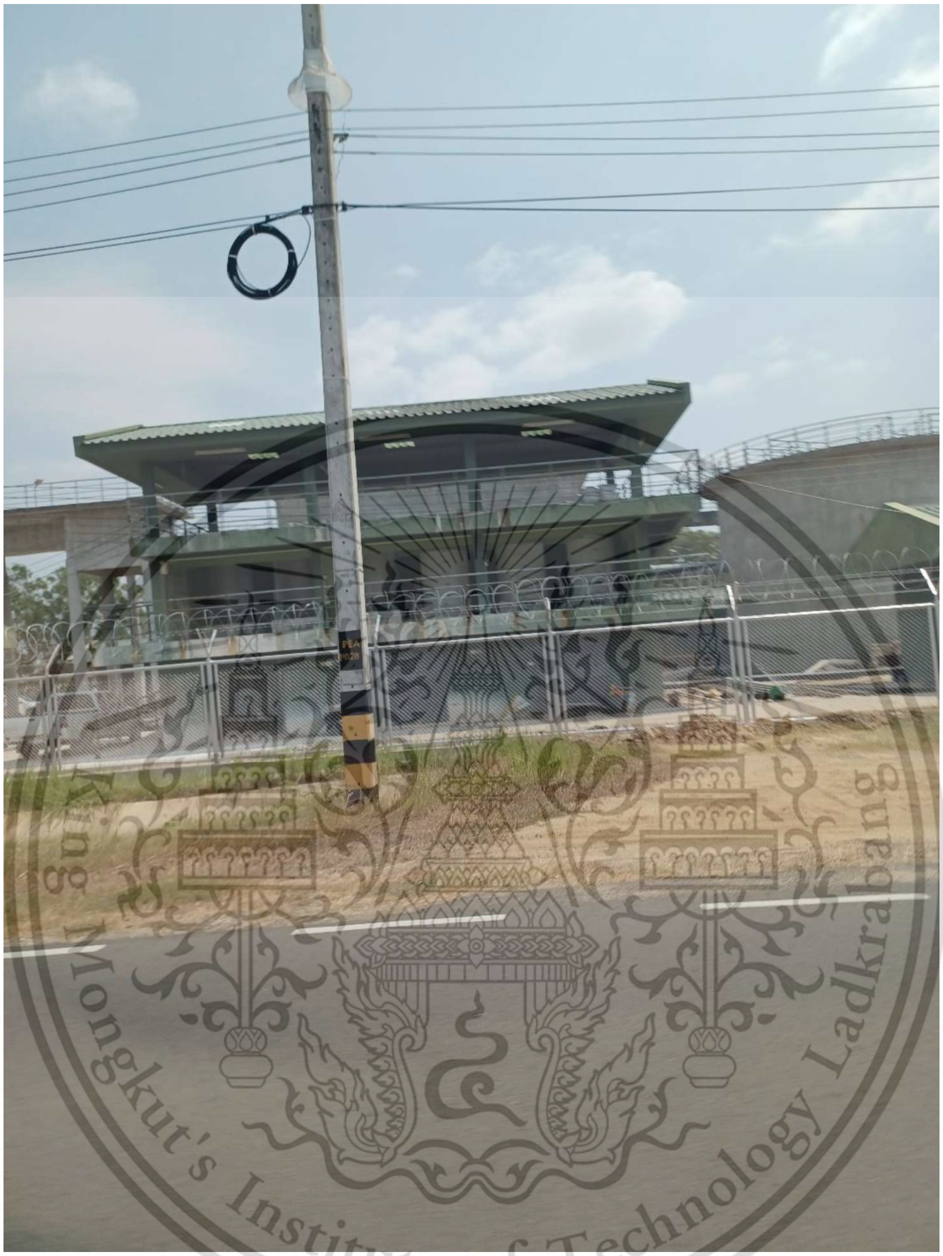

Image 3 : Circumstance of building

Source : researcher (2022)

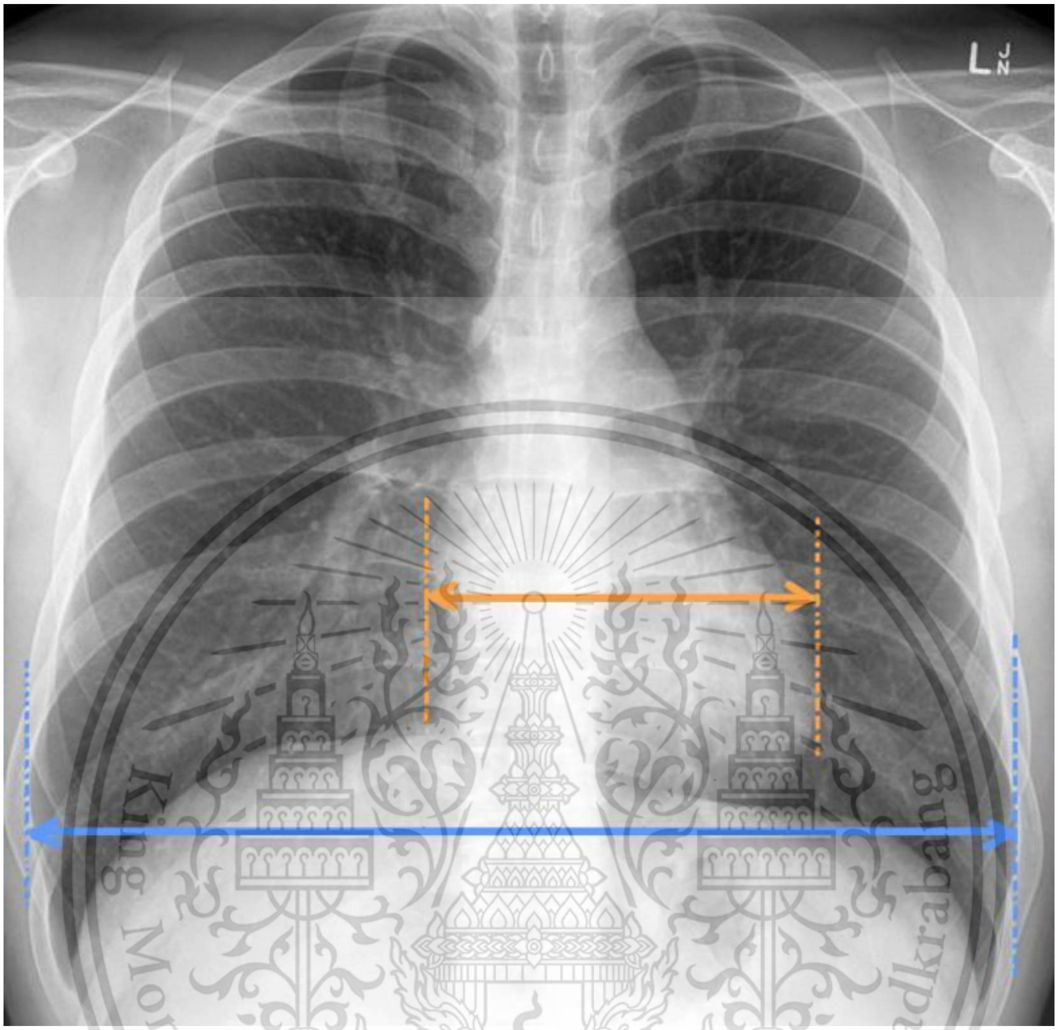

Image 4 : CT ratio

Source : Rohit Sharma (15 Feb 2020)

1.2 Objective

To define if chlorine vaporization is cause by building design and give effect to cardiopulmonary system.

1.3 Research Scope

In this study, researcher focus on chlorine vapor which is occurred in aforementioned building. Gaseous chlorine is poisonous and classified as a pulmonary irritant. It has intermediate water solubility with the capability of causing acute damage to the upper and lower respiratory tract. Today, most incidents of chlorine exposure are through accidental industrial or household exposures. As for industrial exposures, there have been several instances of train accidents carrying liquid chlorine that caused the release of chlorine gas to the surrounding environment. Cardiopulmonary profile of each participate would be collected from medical investigation.

1.4 Methodology

To our knowledge, this prospective cohort study is the first study that has assessed the influence of findings of chest radiography (CXR) on the change in patient management in general practice and evaluated the consequences of the CXR according to the patient. Architectural design would be set as independent factor while health problem would be dependent factors.

1.5 Expected Benefit

To proof our hypothesis that chlorine vaporization would be increase in incompetency architectural design. Moreover, building design would effect chlorine vaporization which effect health system.

1.6 Research Methology

Our research is designed as case controlled study. All will be devided into experimental group and controlled group. Then all parameter from gathering will be analysed with statistical process. T-test will be applied to compared both group.

Chapter 2

Literature review

2.1 Acute and Chronic Effect

Additionally, an interesting phenomenon was observed by comparing the development of the bloody noses and bloody eyes. The bloody noses commonly appeared in the third and in the fourth week; however, approximately two weeks later, this symptom gradually disappeared. The significantly bloody eyes commonly appeared in the ending period of the experiment; however, this problem was becoming worse during the study, and no signs of improvement appeared. The bloody noses appeared first, suggesting that respiratory tracts may be more vulnerable to the irritants from the chlorinated water than eyes; the gradually disappearing symptom suggests that respiratory tracts may have some adaptability to chlorinated water possibly because of the protection from nasal mucous. In contrast, without the mucosal protection, the bloody eyes were becoming increasingly significant during the entire experiment, although this symptom appeared later than the bloody noses.

Therefore, the eyes and skin may be the organs that must be the focus of concern regarding permanent damage induced by irritants from chlorinated water, rather than respiratory tracts, although respiratory symptoms were the most emphasized toxic risk of swimming exposure in recent decades.

Compared with liver damage, lung damage was much more commonly detected under microscopes. This phenomenon, combined with the disappearing bloody noses discussed above, suggests that chlorination disinfection may not be the primary factor for lung damage during swimming because the alveoli and bronchi are also protected by attached mucosal-like respiratory tracts. In contrast, we believe that the training intensity, training frequency and water choking might be the primary factors for the observed lung damage. In this study, both groups of rats were trained similar to competitive swimmers, with high frequency and high intensity, which made them inevitably choke much water and become more vulnerable to lung damage. Similarly, studies of elite swimmers in the United States, Canada, Great Britain, Australia, Finland, and in Ireland confirmed that asthma is more common only among competitive swimmers and was not common among non-competitive swimmers. We suppose that the primary differences between the competitive swimmers and non-competitive swimmers are training intensity and frequency, not the pool water.

Taurine, which is a derivative of cysteine, is called a conditionally essential amino acid and plays many protective roles in the body. Taurine acts as a substrate in the conjugation of bile acids; exerts osmoregulatory, membrane stabilizing, and cytoprotective effects; possesses antioxidative properties; modulates intracellular Ca^{2+} concentration; regulates neurotransmitters and ion movement; and reduces pro-inflammatory cytokines in various organs. As an antioxidant, taurine can directly scavenge hypochlorous acid (HClO) and prevents changes in membrane permeability due to oxidative impairment; as a protector of organs against toxicity, taurine reduces nitrosative stress and oxidative stress by increasing the activities of antioxidant enzymes and intracellular GSH and by normalizing the activities of Na^{+}-K^{+}-ATPase, Ca^{2+}, and Mg^{2+}-ATPase during various toxin-induced pathophysiological conditions.

Creatinine, which is a metabolic byproduct of skeletal muscle creatine and phosphocreatine, is generally eliminated from the kidneys by glomerular filtration with partial tubular excretion. Generally, urinary creatinine excretion is constant in healthy animals, and changes in urine excretion are usually connected with changes in muscle mass or in muscle energy metabolism. Considering that the body weights of the rats are so close between the two groups, the differences in muscle mass should be also slight. Therefore, the elevated level of urine creatinine detected in the EG rats might primarily be related to an unusual muscle energy metabolism.

Apart from taurine, which was discussed above, the second representative metabolites of PC 3 is Hippurate. Thus, PC 3 primarily reflects the changes in acid-base balance.

Hippurate belongs to the uremic toxin family and participates in various physiological processes of energy metabolism and of acid-base balance . Hippurate is an inhibitor of glucose utilization in the muscle and in the kidneys, an inhibitor of glucose utilization in the kidneys and in the liver, a modulator of fatty acid metabolism, and a stimulator of ammoniagenesis. Metabolic acidosis stimulates hippurate synthesis in the liver and in the kidneys and increases urine excretion by the kidneys, whereas alkalinization decreases its synthesis and excretion . The following possible mechanism of hippurate action in the correction of metabolic acidosis was proposed by Dzúrik et al. : Metabolic acidosis stimulates hippurate synthesis and its tubular secretion; hippurate synthesized in the liver is released into the blood, from which hippurate is filtered in the glomeruli and taken up from the interstitium by the organic anion transport system; hippurate synthesized in the kidneys is secreted directly into primary urine; the increased hippurate promotes ammonia production by activating P-independent glutaminase (PIG) at the proximal luminal membrane, which initiates the metabolism of glutamine and of glutamate with ammonia formation, which is a dominant elimination product of H^+.

The first representative metabolite of PC 2 is citrate, followed by taurine and hippurate, which indicates that the elevated urine excretion of citrate might be related to the changes in taurine and hippurate.

Citrate is a dominant product of the tricarboxylic acid cycle (TCA) and occupies a critical crossroad step in the intermediary metabolism of most mammalian cells. Citrate is synthesized in mitochondria and then becomes the entry substrate into the TCA. Its oxidation provides the major source of cellular ATP production; hence, elevated urinary excretion of citrate is an obvious sign of perturbed energy metabolism. Abnormal urinary excretion of citrate indicates mitochondrial inefficiencies in energy production and explains the biochemical basis of excessive fatigue and of weakness . In addition to these roles, citrate also possesses a modulatory function in the correction of acid-base balance, as well as hippurate, because of its anion properties.

Thus, PC 2 primarily reflects the roles of citrate in energy metabolism and in acid-base balance. Considering the differences between the two groups are not significant on PC 2 ($p>0.05$), the modulatory functions of citrate in energy metabolism and in acid-base balance may be not enough to make significant differences.

Chlorine is a necessary element for our bodies, and nontoxic. HClO is the active ingredient of chlorination disinfectants, removing a variety of parasites, bacteria and viruses. However, although attacking microbes and viruses, HClO also reacts with many pool water substances and produces various DBPs. DBPs can be inhaled and ingested during swimming or absorbed dermally, and two classes of DBPs, chloroform and chloramines, have been the focus of most swimming pool studies thus far. Cl_2 inhalation also attenuates myocardial contractile force, reduces systolic and diastolic blood pressures, and causes biventricular failure and death.[7]

When released, the liquid form of chlorine quickly turns into yellow-green colored gas with an irritating odor. Since chlorine is heavier than air, it accumulates in low-lying areas. Chlorine gas has been used as an agent of war as recently as 2007 in Iraq. In 2016, the American Association of Poison Control Centers reported over 6300 exposures to chlorine, making it the most common inhalational irritant in the United States. About 35% of exposures to chlorine gas were attributed to the mixing of household acid with hypochlorite.[8]

Non-respiratory findings may include tachycardia, lacrimation, and salivation.[9] Sloughing of the pulmonary mucosa can occur within 3 to 5 days in severe exposures leading to chemical pneumonitis that can often be complicated by secondary bacterial invasion and infection. Smoking and pre-existing respiratory conditions such as asthma and chronic obstructive pulmonary disease appear to increase the risk of long-term complications such as pulmonary fibrosis.[10]

This reaction forms hypochlorous and hydrochloric acid along with free oxygen radicals. Hypochlorous and hydrochloric acid cause most of the toxic effects attributed to chlorine gas. These acids are produced by the reaction of chlorine (Cl2) with water.[11]

Then, the halation of chlorine vapor during bathing could increases the problem of asthma, allergies, cough, sputum, pulmonary and cardiovascular system which are probably noticed under chest X-ray

Under specific circumstance, portable or bedside radiographs are typically performed by a team of two technologists. The TG-CXR method has the benefit of allowing one technologist to stay outside of the patient room while operating the portable radiography machine, reducing PPE use, decreasing the frequency of radiography machine sanitization and decreasing technologists’ exposures to potentially infectious patients. The cost of implementing this technique during the current pandemic was obtained from our department's operational database. The direct cost of routinely used PPE and sanitization materials and the cost of the time taken by the technologists to clean the machine was used to form a quantitative picture of the benefit associated with TG-CXR technique. Normally, a portable X-ray machine is operated by a team of two technologists. The X-ray machine is brought into patient room where Technologist 1 positions the patient while Technologist 2 operates the machine. Both technologists are required to don a set of PPE prior to entering the room if there is a patient requiring droplet precautions, and both the x-ray machine and the cassette or detector require comprehensive cleaning using sanitary wipes upon exiting the room.

In comparison, the TG-CXR method involves having only Technologist 1 don PPE and enter the isolation room to position the patient and cassette/detector, while Technologist 2 stays with the portable x-ray machine outside of the isolation room. Once the patient is in a satisfactory position, Technologist 1 will provide breathing instructions to the patient, and then signal Technologist 2 to trigger the exposure. While Technologist 1 waits in the isolation room, Technologist 2 confirms that the acquired image is of satisfactory quality. As the portable radiography machine was never in the patient's room, it does not require cleaning. Only the cassette is cleaned and only one set of PPE is utilized instead of two.

The above described method of radiograph acquisition was tested on phantom models at our institution to ensure quality and viability. The imaging parameters were optimized and the technique became the standard of practice in the emergency department of our institution on 23rd March, 2020 in the viral or bacterial infected and PUI population. An official document was created by the x-ray technologist operational leader and the radiologists. The document detailed the protocols for PPE utilization and sanitization for both the conventional portable radiograph method and the portable CXR through glass method. This document was disseminated to all X-ray technologists via institutional network. The TG-CXR technique was also demonstrated by the lead technologists during shift change briefings. The briefings last for up to fifteen minutes and is routine at our institution. The cost of implementation of TG-CXR was obtained from our department's operational database and calculated based on the number of technologists, the training time required, and the per hour average salary of technologists. Cross-sectional review of the hospital PACS of studies identified TG-CXRs performed from March 23, 2020 to April 13, 2020.

To quantitatively assess the benefits of adopting the TG-CXR method, the prices of the routinely consumed PPE including gloves and face shields and sanitization material including disinfectant wipes, alcohol and cotton swabs were obtained from the Procurement Office at our institute. The machine downtime and sanitization resources required for portable X-ray machine cleaning were measured by observation of technologists on three separate instances and mean values were calculated. From our department's operational database, the average salary (including benefits) of X-ray technologists at our institution ($36.16 USD/h) was obtained. The hourly rate for two technologists were multiplied by times saved by reduction in the machine disinfection time/downtime to calculate the financial savings associated with TG-CXR method. There were a total of 316 chest radiographs obtained using the TG-CXR method during the study period– an average of 14.4 imaging studies each day. Given that we have a total of 47 x-ray technologists, the adoption of the TG-CXR technique involved a one-time training cost of $424.88 USD ($9.04 USD per technologist). Through analysis researcher have demonstrated that the implementation of the TG-CXR technique at our emergency department of our hospital involved only a minimal one-time training cost. However, it did yield significant potential net cost saving of over $51,000 USD per year.

Healthcare workers are a scarce resource and keeping them safe is critical to ensure that there is adequate staffing to provide patient care. The TG-CXR technique decreases the number of staff exposed to PUI/COVID positive patients which results in decreased risk of transmission which provides an important advantage during our fight against the current pandemic.

During the current pandemic, hospitals around the world have struggled to maintain adequate PPE supply, making PPE conservation effort critical to maintaining hospital function. The TG-CXR technique uses 50% less PPE than the conventional technique, thereby conserving a valuable resource.

During cleaning, portable X-ray machines are exposed to chemical agents which may result in reduced functionality and increased downtime and maintenance costs. Sensitive surfaces such as the touch screens may be particularly vulnerable to the effects of cleaning agent. Use of TG-CXR decreases the number of cleaning cycles the machines are subject to, which may prolong their usable life and decrease maintenance costs.

A rational next step for expansion of utilization of this technique would be to include emergency patients who are not considered PUIs but are under isolation precautions for other reasons (e.g. C. Difficile, tuberculosis) as well as low immune patients requiring reverse isolation. In the future, the “through glass” technique may be expanded to include imaging studies other than chest radiography (such as abdomen and extremity imaging), yielding increased cost savings. The ease of implementation and cost savings associated with instituting the TG-CXR technique makes a strong argument for its continuation in the post-COVID-19 pandemic era. This technique can continue to provide significant savings as well as reduce healthcare professional exposure to patients isolated for other infectious illnesses requiring isolation precautions.

The study is limited in that we have only used data from a single institution. The exact cost savings will vary by institution as the cost of PPE and technologist salaries do vary from region to region. Given that we provided comprehensive calculation to include all quantifiable aspects of cost-savings, the numerical result from our study can be seen as an achievable upper limit of the projected cost savings a hospital can expect after adapting TG-CXR. Another limitation of the study is the small sample size when recording machine downtime and cleaning supply usage. We also recognize that not all hospitals are built with glass partitions between patient rooms and staff areas and thus through glass technique may not be universally implementable. Leadership of those institutions may consider the benefits of through glass technique in planning the design of future patient care areas. Finally, although a shift change briefing is part of the routine workflow in our hospital, we have presented the one-time cost of implementation to assist other institutes who may have a different workflow. In the landscape of the current pandemic, there are additional benefits associated with adoption of the TG-CXR method that our study methodology could not quantify. These include potential decrease in sick leave, employee healthcare costs and psychological stress from decreased risk of transmission, as well as potential reduction in administrative time, effort and cost required to procure adequate PPE supplies. Then, no any knowledge about chlorine effect to cardiac problem directly as well as building design effect to health problem directly.

Prior knowledge from literature review, chlorine exposure results in a direct chemical toxicity to the airways that is potentiated by the ensuing inflammatory response. Oxidative damage to airways may result during either stage of illness. Acute airways obstruction followed by airways remodeling and/or airways hyperresponsiveness may be seen following chlorine exposures both in animal models and in humans. The results of human chlorine inhalation may range from acute overwhelming intoxication with acute lung injury and/or death to intermittent or repeated accidental or unintentional occupational exposure. The latter tends to result in greatly increased hazard ratios for chronic bronchitis or isolated wheezing attacks, but with less likelihood of development of clinical asthma than occurs in those with occupational exposures to ozone. Cigarette smokers may be particularly vulnerable to these results of occupational chlorine inhalation exposures. Alternatively, lung damage due to chlorine and that due to smoking could be additive or synergistic. Chronic low-level exposures to chlorine also may be associated with considerably greater odds ratios for having or developing asthma, hay fever, and allergic rhinitis in vulnerable atopic populations exposed to chlorinated, but not copper-silver-treated, swimming pools. There is no evidence that youth protects against such insults, or that it necessarily carries excessive risk of poor outcomes. Thus, while those fortunate to survive acute severe chlorine inhalation may eventually be left without pulmonary disability, a pattern of findings indicates that specific vulnerable populations of individuals such as smokers and atopic individuals may suffer from chronic respiratory disorders resulting from less profound unintentional exposures. At present, recommended treatment of persons suffering from acute accidental chlorine inhalation exposures is supportive and symptomatic. Development of new therapies, with trials in appropriate models, could lead to improvements in care of these individuals.[12]

Humans exposed to high doses of chlorine can develop acute lung injury characterized by pulmonary edema, bilateral infiltrates on chest X-ray, hypoxemia, and respiratory failure. Exposure to lower doses of chlorine can predominantly produce airway injury and obstruction without development of acute lung injury. Treatment for acute lung injury induced by chlorine inhalation includes supportive care, such as oxygen administration and mechanical ventilation. Although no drugs are approved specifically for the indication of chemical-induced acute lung injury and/or airway obstruction, victims of chlorine poisoning are typically treated for acute effects with multiple drugs approved for other lung diseases. These include systemic and inhaled corticosteroids as anti-inflammatory measures, adrenergic and anticholinergic bronchodilators to ameliorate airway obstruction, and nebulized sodium bicarbonate, which is intended to neutralize the acidic effects of chlorine in the respiratory tract. Therapeutic strategies for persistent chlorine-induced lung disease can be focused on postexposure treatment to prevent the development of persistent disease or on treatment that starts once persistent disease is established. Preventative treatment studies have been performed in rat models. Treatment with the corticosteroid dexamethasone for 7 days after chlorine exposure inhibited inflammation and improved lung function. Chlorine-exposed rats treated with antioxidant therapy showed reduced airway remodeling and airway hyperreactivity 7 days after exposure. Chlorine-exposed dogs developed inflammatory bronchiolar lesions that progressed to bronchiolitis obliterans with intraluminal fibrosis, but no treatment was tested in this study. A recent publication reported human clinical cases of inflammatory bronchiolitis obliterans lesions with incipient fibrosis of unknown causes that were effectively treated with corticosteroids. If such lesions develop in human lungs after chlorine exposure as in the animal model, then corticosteroids may represent a possible treatment that could be tested to prevent the development of persistent chlorine-induced lung disease. In humans, recommended treatment for RADS/acute irritant-induced asthma once established is similar to that for asthma generally (i.e., bronchodilators and systemic corticosteroids for management of acute exacerbations and inhaled corticosteroids with bronchodilators if necessary for chronic maintenance therapy). However, patients treated with these agents can continue to exhibit abnormal lung function.[13,14] Thus, these measures may control symptoms, but do not appear to reverse or ameliorate the underlying disease pathogenesis.

Accidental exposures to chlorine, although sporadic, are not uncommon. Concerns also remain that chlorine may be released in warfare and terrorist attacks. Acute effects have been well characterized and may include dyspnea, hypoxemia, pneumonitis, and pulmonary edema. Following recovery from acute chlorine injury, persistent effects may be observed in some individuals. More information is needed to fully understand the types of persistent effects that chlorine can have on the respiratory system, but evidence to date indicates that these primarily involve airway disease. Animal models indicate the development of airway injury, inflammation, impaired repair, and airway remodeling, including fibrosis, but additional models are needed that better represent persistent disease in humans. Little information is available about the actual benefits of potential treatments (e.g., bronchodilators and corticosteroids), so more research is needed in this area, both in preventing development and in treating or reversing established disease. A chronic inflammatory process in injured airways appears to be a hallmark after chlorine exposure, so anti-inflammatory measures during critical postexposure windows may represent a possible therapeutic strategy to prevent the development of persistent chlorine-induced lung disease.

Because of the challenges in understanding the persistent effects of chlorine exposure in humans, animal studies, in which chlorine exposure levels and analysis end points can be experimentally controlled, have been pursued. Chlorine inhalation injures the cells lining the respiratory tract, and this damage must be repaired to reestablish normal lung structure and function. Long-term impairment in lung function following irritant gas exposure is likely to be caused by the failure of repair processes to return the structure of the lung to its normal state. Hence, studying the repair of the respiratory tract after chlorine inhalation is instructive for understanding how persistent disease may develop and for developing therapeutic interventions. Damage to the airway epithelium is a common manifestation of chlorine lung injury that has been observed in multiple animal models. At low doses of chlorine (e.g., 100 ppm for 5 min), functional alterations can be observed in the absence of gross changes in airway histology, but increased protein leak under these conditions indicated some type of epithelial damage, such as impaired barrier function, in the absence of frank cell death. Widespread death and sloughing of airway epithelial cells has been a consistently observed feature in models utilizing higher doses of chlorine (240–1500 ppm for 5–60 min) that result in acute lung injury. Depending on the dose, chlorine can damage the entire extent of the airway epithelium, from the nasal passages to the terminal bronchioles. The process by which the pseudostratified epithelium in larger airways is repaired after chlorine injury has been examined in detail in mice. Chlorine doses that produce acute lung injury (240 ppm for 60 min or 350 ppm for 30 min in these studies) result in the death and sloughing of most epithelial cells from the pseudostratified epithelium, including virtually all club and ciliated cells. Basal epithelial cells that survive the exposure spread to cover the wounded area within a day after exposure. The basal cells act as progenitor cells to carry out repair; they undergo a burst of cellular proliferation during the period of 2–4 days after exposure, followed by a period of differentiation 5–10 days after exposure to restore a pseudostratified epithelium that again contains basal, club, and ciliated cells. The overall process is similar to that observed following inhalation of other irritant gases, such as sulfur dioxide, and is likely to be the main process by which the airway epithelium is repaired in human lung, as the pseudostratified epithelium in humans penetrates for multiple generations of branching into smaller bronchioles. Repair of simple epithelium in smaller airways has not been investigated in detail following chlorine exposure, but is likely to involve surviving club cells that act as progenitors to restore the epithelium, as has been observed in other injury models.[15]

2.2 Accidental Inhalation

Several previous reports had reported accidents of inhalation injuries at swimming pools. However, there have been limited data on the detection of on-site chlorine concentration. This study aims to report a chlorine leakage accident at a swimming pool caused by improper disinfection operations. Calculation using the gas diffusion simulation software showed that the on-site chlorine concentration was 221.45 ppm. When the accident occurred, there were 92 individuals at the swimming pool and the gym, among which 61 were referred to the emergency department of five different hospitals for feeling ill. Among them, 22 patients underwent chest high-resolution computed tomography scans in our hospital. According to the findings, 4 (18.2%) patients had peribronchitis, 3 (13.6%) had tracheobronchitis, 4 (18.2%) had pneumonia, 4 (18.2%) had interstitial pulmonary edema, and 3 (13.6%) had alveolar pulmonary edema. The symptoms of 22 patients who visited our hospital significantly improved after comprehensive treatment. Three months after the accident, 8 of 17 patients presented obstructive ventilation defects or small airway dysfunction. The accidental exposure to chlorine may induce acute poisoning with various respiratory injuries and prolonged lung dysfunction.[16,17]

Focusing on age group, acute exposure to chlorine causes lung damage, and recovery may proceed slowly for several weeks. The short term respiratory effects of acute chlorine inhalation during a swimming pool accident were examined. Separate analyses were performed for children (<14 years old) and adults (⩾14 years old). The occurrence of acute symptoms (eye irritation, nose and throat problems, shortness of breath, wheezing, cough) was described relative to levels of exposure . Both time to vacate the pool and perception of exposure were tested separately. Pearson's χ^2 test was used to compare percentages of respiratory symptoms at 15–30 days across different categories. The effects on lung function were analysed through a multiple linear regression separately in the two age groups, as there may have been an age specific size of the effect. Lung function measures (natural logarithm (ln) transformed) were regressed on sex, age (ln_{age}), height (ln_{height}), body mass index (BMI, weight/height^2; ln_{BMI}), history of chronic respiratory disease, instrument, physician performing the examination, and smoking among adults. Moreover, a variable indicating the number of days since the accident was calculated for each person and added in the model to take into account the potential recovery of lung function over time. We calculated the ln of all lung function values because of their skewed distribution in our sample and the heteroscedastic relation between lung function and its predictors. In a second step, the exponential residuals from the two linear regression models were calculated and then regressed on the exposure variables so as to derive age specific and combined effect estimates. Dummy variables for the exposure variable (the lowest level being the reference group) were generated. Slightly higher effect estimates were obtained for models including perception of exposure, which was then preferred as the exposure variable. The results were expressed as the mean adjusted ml differences between the lung function values in the exposed people and the values in the reference group. Acute respiratory symptoms occurred among 66.7% of adults and 71.6% of children. The incidences were highest among those who had chronic respiratory disease and had a longer duration of exposure. In about 30% of the subjects, respiratory symptoms persisted for 15–30 days after the accident. Lung function levels were lower in those who reported a high intensity of exposure than in those who reported low exposure, both in children and in adults (mean (95% confidence interval (95% CI)) differences in forced expiratory volume in 1 second ($FEV_{1,}$) were −109 (−310 to 93) ml, and −275 (−510 to −40) ml, respectively). The present study documents that short term exposure to chlorine due to a swimming pool accident can cause significant immediate morbidity in most exposed people and potential lung damage after 15–30 days. Although we did not know the exact concentration of the inhaled chlorine vapours, a mild degree of exposure can be hypothesised as the accident happened in a closed space and most people escaped outside in a few minutes. The immediate clinical manifestation in most people was predominantly due to the irritant effect of chlorine gas on the lachrymal, nasal, oral, and tracheobronchial tree.

Inhalation of chlorine gas can damage both the airways and the alveolar-capillary structures because of its solubility. At physiological pH on most surfaces, chlorine gas combines with tissue water to form hydrochloric and hypochlorous acids which diffuse into cells to react with the amino groups of cytoplasm proteins, forming N-chloral derivatives. During these chemical reactions, nascent oxygen is released. Oxidative effects are responsible for the main cytotoxic damage, and the acid production for secondary irritation. The variations in the type and amount of injury are related to the concentration of chlorine gas, the duration of exposure, the treatment given, and the individual susceptibility.

Short term symptoms after acute exposure to chlorine have been previously documented especially in occupational environments but also during community accidents. Decker *et al*described two accidents in the same swimming pool, the first involving 30 people in 1986 and the second 11 people in 1988 in Texas; those exposed to heavy concentrations of chlorine gas developed classic early signs and symptoms of acute exposure. Two children, after brief exposure to fumes from solid chlorine products used in residential pools in Nebraska in 1986, developed lethargy, productive cough, severe hypoxaemia, tachypnoea, cyanosis, retraction, and expiratory wheezes and crackles in the base of the lungs. After acute exposure to chlorine from two separate accidents in community pools in Pennsylvania in 1996, all 13 children involved showed not only classic signs and symptoms, but also a fall in blood oxygenation saturation.

We found some lung function impairment 15–30 days after the accident as a result of injury to lung parenchyma and small airways. Our findings of a short term effect (within 1 month) can be compared with other studies, in most of which lung function decrements tended to disappear after a few weeks. Ploysongsang *et al* found restrictive ventilatory function with reduced diffusing capacity and some obstruction in small but not in large airways 14–16 hours after the exposure of four healthy men in a swimming pool in Ohio in 1982; all impairment of lung function cleared within 1 month without residual lung damage. Hasan *et al* described lung function deficit in 18 asymptomatic subjects accidentally exposed to chlorine in a dormitory in Lebanon in 1983 at 1, 7, and 14 days after the exposure; a reduction of the flow rates was found, which cleared at 15 days in 12 subjects. Both obstructive and restrictive impairment have been documented which could possibly be related to different degrees and durations of exposure as well as different individual susceptibility and reaction to a noxious agent.

Although most studies did not have long term sequelae of a single high dose exposure, the debate on this issue is still open. On the one hand, Jones *et al* did not find any evidence of an exposure effect on the annual rates of change over 2 years among the 84 victims of a train derailment with chlorine gas diffusion which occurred in Florida in 1978. Abhyankar*et al* described an accidental exposure to chlorine in an open space among eight people in India in 1985 and found that at 6 months all the spirometric measures had returned to normal values. On the other hand, Brooks *et al* documented that in some people acute high level irritant exposure may cause an asthma-like syndrome, reactive airway dysfunction syndrome, which is different from typical occupational asthma, and can lead to chronic airway disease. Although the exact pathological change is not known, bronchiolitis obliterans has been proposed as a lesion occurring after some toxic gas inhalation. A typical feature of reactive airway dysfunction syndrome has been experienced by three German policemen without history of respiratory disease 4 months after an accidental exposure to chlorine, but more consistent evidence of long term lung damage after acute accidental exposure to chlorine has been documented in occupational settings. It has been hypothesised that low background levels of the respiratory irritants among workers cause a chronic inflammatory response in the small airways that may enhance the effects of a single acute gassing episode with a higher possibility of long term sequelae than in other settings. There are treatment of this situation with nebulized corticosteroids immediately after chlorine gas injury. Eighteen anesthetized and mechanically ventilated pigs were exposed to chlorine gas (140 ppm for 10 minutes) and observed for 6 hours. Nine pigs were treated with nebulized beclomethasone-dipropionate 20 microg/kg (BDP group), and nine pigs were given no treatment (control group). All animals developed severe pulmonary dysfunction. The initial decrease in PaO_2 was similar in both groups, but BDP-treated animals improved whereas control animals deteriorated ($p < 0.005$; analysis of variance). Pulmonary vascular resistance increased in both groups but less in the BDP group ($p < 0.01$). Lung-thorax compliance was better preserved in the BDP group ($p < 0.01$), and oxygen delivery was significantly better in the BDP group ($p < 0.01$). One animal died in the BDP group, as did three animals in the control group. Immediate treatment with nebulized BDP improved pulmonary and cardiovascular function after experimental chlorine gas injury. Moreover, chlorine gas inhalation, similar to other toxic gas exposures, can impart a variety of effects to the entire airway ranging from mucous membrane irritation to acute respiratory distress syndrome. The extent and location of damage is determined by numerous situational factors such as the duration of exposure, quantity of gas released, environmental factors, and instituted chemical defense measures. Reactive airways dysfunction and nonspecific bronchial hyperresponsiveness are commonly reported as sequelae to chlorine exposure. This article constitutes the first case of a single antecedent chlorine exposure inducing progressive vocal cord dysfunction.

We found greater effects of exposure to chlorine among those with a history of respiratory and atopic disorders. A pre-existing airway hyperresponsiveness could be responsible for an exaggerated pulmonary response to chlorine gas inhalation. Subjects who had a history of asthma or wheezing had the lowest FEV_1 and FVC together with a slower resolution of symptoms after the accidental exposure in a dormitory. A case of asthma persisting 2 years after the inhalation of a mixture of sodium hypochlorite and hydrochloric acid was documented in a woman with a familial history of atopic disease. Finally, we found that smokers tended to have persistent respiratory symptoms at 15–30 days and greater lung function decrements than non-smokers. Smoking might act in conjunction with irritant gas to cause an inflammatory reaction in the small airways and reduce ventilatory function.[18]

Persistent symptoms and lung function impairment were found up to 1 month after the incident. Although community pool accidents happen rarely, the medical community needs to be alerted to the possible clinical and physiological sequelae, especially among susceptible people.[19]

2.3 Benefit of Chest X-ray on chlorine gaseous injury to the lung

Focusing on chest x-ray examination, there is research which analyzed 27 cases of acute chlorine gas poisoning patients with chest X-ray, CTand chest clinical manifestations. To investigate the relationship between the chestimaging and clinical manifestations.Materials and Methods Chest X-ray and CT were obtained in 27 patients with acute chlorine gas poisoning.Then chest X-ray, CT and clinical manifestations were analyzed. The improved acutelung injury score sheet items was used to get the X-ray, CT and clinical manifestations score from the diagnosed patients.Results According to the national occupational diagnostic criteria of acute chlorine gas poisoning of PRC (GBZ65-2002), 9 patients were diagnosed as chlorine gas inhalationirritations, 3 patients were diagnosed as mild poisoning, 4 patients were diagnosed asmoderate poisoning, 11 patients were diagnosed as severe poisoning. Among 18 patientswho were diagnosed as chlorine gas poisoning, 13 patients' chest CT and X-ray wereconsistent with the clinical manifestations. 5 patients hadn't obvious abnormalities inchest X-ray or performance less serious, but the clinical manifestations showed moreserious which was consistent with CT. The CT score peak appeared earlier than clinicalmanifestations. The X-ray score peak lagged behind clinical manifestations. During therecovery process, CT and X-ray score were closer; they remained at a high value whenthe clinical score had been significantly improved.Conclusion The chest X ray and CT can reflect the degree of acute chlorine gas poisoning; theyare closely related with the clinical manifestations. Chest CT showed lesions earlier thanchest X-ray, even earlier than clinical symptoms and signs. The diagnostic value of CT issuperior to chest X-ray; it is recommended that take chest CT examination as early aspossible in acute chlorine gas poisoning patients and add chest CT examination to thenational occupational diagnostic criteria of acute chlorine gas poisoning of PRC.[20] Some reports a thorough investigation of the sociodemographic characteristics, clinical findings, and treatment of persons affected acutely by chlorine gas exposure from a chlorine tank belonging to the municipality of Diyarbakir. One hundred six persons were assessed. In this cross-sectional study, 58 patients were male and 48 were female. Children and adolescents younger than 18 years constituted more than half of the patients (60 cases, 56.6%). The age of patients ranged between 3 months and 75 years. Among the cases evaluated in emergency rooms, 7 patients had mild poisoning and were discharged after first examinations and symptomatic treatments, 62 patients were moderately affected and were taken under observation, and the remaining 37 were severely affected and were hospitalized. In physical examinations, 29 patients had expiratory wheezing, and 1 had tachycardia and extrasystoles. There were no deaths among these patients, acute chlorine intoxication affected mostly children. Respiratory tract findings were predominant in most of the patients.

Steroid and bicarbonate applications were inadequate supportive therapies. Humidified O(2) and beta-agonist applications were most useful in the therapy of acute chlorine intoxication. Some conducted a review of the literature detailing the respiratory effects of chlorine, an extremely important but toxic halogen. Historically, the heaviest mass inhalational exposures to chlorine resulted from World War I gassing. Currently potential human exposure to chlorine inhalation occurs in a variety of settings in the workplace, as a result of inadvertent environmental releases, and even in the home due to household cleaning mishaps. Chlorine species are highly reactive; tissue injury results from exposure to chlorine, hydrochloric acid, hypochlorous acid, or chloramines. Acute, high level exposure to chlorine gas in occupational or environmental settings results in a variety of dose-related lung effects ranging from respiratory mucus membrane irritation to pulmonary edema. Pulmonary function testing can reveal either obstructive or restrictive deficits immediately following exposure, with resolution over time in the majority of cases. However, some of those exposed may demonstrate long-term persistent obstructive or restrictive pulmonary deficits or increased nonspecific airway reactivity after high level exposure to chlorine gas. Symptoms and signs following inhalation of mixtures of chlorine-containing cleaners in the home are similar to those after occupational exposures and environmental releases. Although generally less severe, these events may be extremely common. Controlled human exposure data suggest that some subjects may be more responsive to the effects of chlorine gas; epidemiologic data also indicate that certain subpopulations (e.g., smokers) may be at greater risk of adverse outcome after chlorine inhalation. Although these findings are intriguing, additional study is needed to better delineate the risk factors that predispose toward the development of long-term pulmonary sequelae following chlorine gas exposure. Moreover, there are report about previously healthy 23-year-old man with nonproductive cough and sore throat presented to the hospital a few hours after chlorine gas exposure at a fitness center swimming pool. Initial physical examination and chest radiograph were normal. Thirty-six hours later he developed worsening dyspnea and cough, with development of blood-tinged sputum. Arterial blood gas analysis showed mild hypoxemia and a subsequent chest radiograph demonstrated diffuse tiny nodular opacities. Findings on a thin-section computed tomogram of the chest were consistent with diffuse bronchiolitis. Pulmonary function tests showed a mild obstructive abnormality and he demonstrated substantial bronchodilator response.

2.4 Other modality

Computed tomography (CT) has been a boon for medical care. By generating detailed anatomical pictures, the technology can improve diagnoses, limit unneeded medical procedures, and enhance treatment. However, CT scans also dose patients with ionizing radiation, a known human carcinogen, posing a potential downside for public health. Mounting health worries over radiation risks are now driving efforts to limit avoidable CT scans and to reduce radiation doses where possible. “There’s a national focus on this issue right now,” says Marilyn Goske, a professor of radiology at Cincinnati Children’s Hospital Medical Center and chairwoman of the Image Gently campaign, a pediatric education and awareness campaign from the Alliance for Radiation Safety in Pediatric Imaging.

In December 2011 the Institute of Medicine (IOM) published a report concluding that ionizing radiation contributes more to the development of breast cancer than any other type of routine environmental exposure. About half the U.S. annual exposure to ionizing radiation comes from natural sources, including cosmic rays, but most of the rest comes from medical imaging and from CT scans in particular. The IOM cited research by Amy Berrington de González, a senior investigator in the Radiation Epidemiology Branch of the National Cancer Institute (NCI), whose calculations suggest that the CT scans performed in the United States in 2007 might produce up to 29,000 cancers in the future, about 6% of them in the breast and the remainder in the lungs, brain, and other organs.

But the spotlight on CT safety has also drawn a backlash from those who say the risks are overblown. On 13 December 2011 the American Association of Physicists in Medicine (AAPM) issued a statement claiming that risks from CT imaging are “too low to be detectible and may be non-existent.” The AAPM added that “speculative predictions about cancer incidence and death” should be discouraged because they generate sensationalist media coverage that deters some patients who need CT scans from having them.

Donald Miller, acting chief of the Diagnostic Devices Branch of the U.S. Food and Drug Administration (FDA) Center for Devices and Radiological Health, cites 2 basic principles for decreasing CT radiation risks. One is justification, which refers to prescribing a CT exam only when it is medically necessary. The other is optimization, which refers to adjusting and operating a CT scanner so that images adequate for diagnosis are obtained at the lowest possible dose. Justification is more difficult to address, Miller says, because it involves case-by-case decisions made by individual clinicians. More attention has been paid to optimization, he says, but both principles are equally important.

Chest radiography (CXR) is an important diagnostic method for evaluation of the airways, pulmonary parenchyma and vessels, mediastinum, heart, pleura and chest wall. It is one of the most widely used diagnostic imaging techniques in Western societies; on average 236 CXRs per 1000 patients per year are performed and this technique accounts for 25% of the annual total numbers of diagnostic imaging procedures. In the Netherlands, annually approximately 500 000 CXRs are requested by GPs. The frequency with which even relatively inexpensive and non-invasive diagnostic tests are performed leads to high costs in health care. Unnecessary diagnostic investigations may lead to incidental findings, or to additional unnecessary diagnostic procedures or even over treatment.

Current guidelines for CXR are aimed mainly at diseases instead of at the complaints with which patients present themselves, and even lacking in the Netherlands. We are aware of only few studies on CXR in patients referred by GPs. Geitung *et al* concluded that the clinical utility of CXR was high enough to justify its costs, and Lim *et al* showed that GPs do act on results of abnormal CXRs. The studies of Guyer *et al* and Keogan *et al* reported clinically relevant abnormalities in 21 and 23% of patients referred for CXR by GPs, respectively. Clearly, the full value of CXR cannot be assessed in terms of positive findings alone. The relevance of detected abnormalities must be assessed with respect to clinical practice, because positive findings may be incidental and without any consequences. Negative examinations can also have potential value when they result in changes of patient management and can be very helpful in reassuring the patient. Neither of these studies cited both positive and negative findings in detail, nor assessed the value of CXR in terms of changes in patient management.

Some previous works also developed methods to relabel public large datasets or constructed a new one. Wang et al. proposed a method for extracting a hospital-scale CXR dataset from the PACS via an unified weakly-supervised multi-label image classification and disease localization formulation by applying natural language processing (NLP) techniques. NegBio , a rule-based algorithm that utilizes universal dependencies and subgraph matching, known as providing regular expression infrastructure for negation and uncertain detection in radiology reports. Filice et al. investigated the benefit of utilizing AI models to create annotations for review before adjudication in order to speed up the annotation process while sacrificing specificity. Johnson et al. extracted and classified mentions from the associated reports using two NLP tools, CheXpert and NegBio, before aggregating them to arrive at the final label. To construct structured labels for the images, Irvin et al. created an automated rule-based labeler to extract observations and capture uncertainties contained in free-text radiology reports. Padchest labeled the majority of the dataset using a recurrent neural network with an attention mechanism. This dataset contains excerpts from Spanish radiology reports, however the labels have been mapped to biological vocabulary unique identifier codes, making the resource useful regardless of the language. RadGraph introduced a new dataset of clinical entities and relations annotated in full-text radiology reports taken from CheXpert and MIMIC. This research made use of a novel information extraction schema that extracts clinically relevant information associated with a radiologist's interpretation of a medical image.

Other than the above-mentioned differences in labeling methods, our label selection is also different from previous studies. So far, most of the studies were developed for classifying common thoracic pathologies or localizing multiple classes of lesions. For instance, most deep learning models were developed on the MIMIC-CXR and CheXpert datasets for classifying 14 common thoracic pathologies on CXRs in recent years. The earlier dataset Chest X-ray14, an expansion of Chest X-ray8, including the same set of 14 findings has been used to develop deep learning models. Nevertheless, these approaches are far different from how Vietnamese radiologists work. In clinical practice, a CXR radiology report always includes four descriptions that correlate to four fixed anatomical regions of the thorax: chest wall, pleura, pulmonary parenchyma and cardiac. Therefore, it is not practical for Vietnamese radiologists to utilize a CAD system that provides suggestions for the presence of 14 diseases. Typically, when examining a CXR image, radiologists analyze that image by region; consequently, it is more convenient for the system to indicate the abnormality of each area, eliminating the need to match the lesion type with the region being viewed. To address the realistic demand of Vietnamese radiologists, we developed a system to classify CXRs into 5 classes depending on the position of pathologies: chest wall, pleura, parenchyma, cardiac abnormality and the existence of abnormalities in the CXRs, if any. When tested on the benchmark CheXpert dataset, we found that this coarse classification produces results comparable to the detailed classifier of 14 findings in terms of abnormal class and gives better results in terms of macro average F1 score of all classes.

When comparing CT to CXR-screening. Consequently, CT-screening is now being incorporated into clinical practice. Nonetheless, questions about the value of CT-screening remain given costs of CT and workup of false-positives. A prior cost-effectiveness analysis of CT-screening using NLST data concluded that CT was generally cost-effective. That analysis was performed under the assumption that CXR-screening only added costs without benefit. In an independent analysis of PLCO comparing CXR to no screening, we found that CXR-screening is associated with a highly significant LC survival advantage. This benefit was unrelated to conventional screening biases, including overdiagnosis. As CXR is less expensive than CT with a lower false-positive rate, its cost-effectiveness relative to CT should be assessed. Data from PLCO and NLST allows comparison of no screening, CXR, and CT.

While chest X-ray (CXR) is a standard diagnostic procedure in patients suspected of non-traumatic pulmonary disease at the emergency department (ED), chest CT highlights chest pathology better than CXR. Studies in patients with possible community-acquired pneumonia (CAP) and other non-traumatic pulmonary diseases have demonstrated that the diagnostic accuracy of CXR is limited. Three studies showed CT markedly improved diagnostic accuracy, and subsequently changed diagnoses and clinical management. CT also requires more radiation and increases the risk of radiation-induced cancer. Ultra-low-dose chest-CT (ULDCT; dose <1 mSv) has overcome this disadvantage, while preserving diagnostic accuracy for many acute pulmonary diseases that present at the ED, like pneumonia and congestive heart failure.

The use of ULDCT reduced false-positive and false-negative CXR findings with consequences for clinical management by 20% in a prospective study in an outpatient setting. Yet ULDCT is still more expensive and less accessible than CXR, and incidental findings are more prevalent. While the superior diagnostic accuracy could lead to faster detection of underlying conditions and timely initiation of effective treatment, incidental findings detected on ULDCT could also complicate healthcare processes, potentially prolonging hospital stay.

The value of a diagnostic test is not expressed by its accuracy but depends on how it affects patients health. New tests should only be introduced into clinical practice when they have demonstrated to impact clinical decision-making, resulting in better patient health outcomes or a simplification of the healthcare process. Diagnostic imaging technologies that affect large numbers of patients and hold the potential to substantially increase healthcare costs require more extensive and more robust data on outcomes than those without these attributes.

Comparison between Chest X-ray and other modality

The similarity in health outcomes with CXR and ULDCT, despite the well-documented lower diagnostic accuracy of CXR, is likely explained by CXR’s ability to detect the most relevant diagnoses in ED patients. In case a presumed clinical diagnosis is not confirmed by CXR, the attending physician may decide to prompt treatment nonetheless, or perform additional imaging. Indeed, in our study CXR patients underwent significantly more additional imaging procedures within 28 days than in ULDCT patients.

As expected, more ULDCT patients had incidental findings and more were in follow-up because of these findings at 28 days, mostly due to pulmonary nodules. The number of clinically relevant incidental pulmonary nodules and patients in follow-up at day 28 is lower than in previous studies. In a retrospective study of 1000 CT pulmonary angiographies ordered at the ED in a group of patients with an age distribution comparable to our ULDCT cohort, 9.9% of the patients with incidental pulmonary nodules required follow-up, compared with 4.1% in our study. This difference is very likely due to differences in comorbidities between both cohorts.

The use of computer-aided diagnosis for lung nodule detection can aid in the detection and follow-up of clinical relevant incidental pulmonary nodules, especially in the hectic work environment of the ED, but the software was not yet available in the radiology departments during our trial. Further studies should evaluate the added value of artificial intelligence in this setting. The impact of incidental findings on long-term functional health could not be assessed in our trial because of the limited follow-up period.

As mentioned study included consecutive ED patients, study limitations are mostly inherent to the demanding workflow at the ED, which sometimes interfered with obtaining informed consent and the logistics to perform ULDCT. Due to the pragmatic nature of this trial, concealment of allocation was not possible. This could have potentially led to information and selection biases. It may explain the higher number of patients with a clinical suspicion of bronchitis for ULDCT and the higher number of patients with possible pulmonary congestion and pneumothorax for CXR. The higher number of patients with a baseline comorbidity of asthma in the ULDCT group, and the resulting higher number of patients with a day 28 diagnosis of asthma exacerbation in the ULDCT group, are probably due to a seasonal increase of asthma exacerbations in the months February, March and April, when ULDCT was more often the allocated method. However, the similarity in baseline characteristics and presenting symptoms in both study groups indicates that this was unlikely to result in a systematic bias in our study. The SF-12 questionnaire response (ULDCT 77.2% and CXR 71.6%) was, despite many efforts, lower than anticipated but higher than in earlier studies at the ED. However, there were only minor differences in baseline characteristics between responders and non-responders.

Researcher designed this study as a non-inferiority trial, since we anticipated that the superior accuracy of ULDCT would lead to health outcomes at least as good as after CXR, with a more efficient healthcare process. The point estimate of the mean difference between the two groups shows a 1.1 point difference in mean PCS score in favour of ULDCT. With more returned questionnaires, the precision in this estimate would have been larger and power increased, potentially demonstrating statistically significant superiority of the ULDCT strategy. However, other modality may give higher resolution and more detail for abnormality detection but due to advanced technology, CT scan may not be investigation of choice for early screening for this research.

2.5 Inter-reader variability

Multiple radiologists with different levels of experience in chest imaging were involved in reading the ULDCT and CXR examinations for this study. This has caused inter-reader variability, although the low proportion of initial reports adjusted by the supervisor (1.0% ULDCTs and 0.6% CXRs) shows that reporting was largely consistent.

This study was performed before the outbreak of the corona virus infectious pandemic. The pandemic changed the incidence, presentation and management of patients suspected of CAP compared with the usual situation, which is not accounted for in our study.

Improved diagnostic accuracy on itself does not automatically translate to improved patient outcomes, as the impact of imaging depends on the outcome of clinical interventions that follow. It is therefore argued that significant changes in treatment planning and a meaningful change in patient outcome should be documented for new radiological applications to be accepted. Our study showed that ULDCT leads to no marked effect on healthcare efficiency, in terms of number of admissions and hospital length of stay or on short-term health outcomes, in the broad population of ED patients suspected of non-traumatic pulmonary disease. Furthermore, ULDCT has higher immediate imaging costs than CXR while both the examination and reading require more time, which might be a disadvantage at a busy ED. The findings in this trial enforce the current guidelines which adhere to CXR as first-line imaging technique in ED patients suspected of non-traumatic pulmonary disease. Considering the availability and costs of ULDCT, the results of aforementioned trial do not support the routine use of ULDCT in the work-up of patients presenting with non-traumatic pulmonary disease at the ED. Eventhough, there are good benefit of ULDCT but our study of chlorinated inhalation choose CXR because of cost effectiveness as described. In summary, temperature affects rate of chlorine vaporization while aging might be another factor which may effect health worker while expose to chlorine vapor as well.

Chapter 3

Material and Method

After literature review, the most suitable question is how chlorinated vapor could effect human lungs in long term. That would be interesting if research could answer the question of chlorine effect separated by age group and timing of exposure.

Due to case-controlled study design, data gathering are collected from chest x-ray. Group of experiment are divided into control group and experimental group. Control group is group of people who do not work in aforementioned worksite while experimental group is exposure group who expose with chlorine and air craft pollution without safety architectural design. Our case-controlled study had 103 patients which include 52 patients in control group and 51 patients in experimental group. Criteria of exposure group in poor architectural design are no temperature control but almost of temperature in working hour is over than 30 degree Celsius, no evaporation control which has no partition or any wall to prevent chlorine vapor and exposure of worker during chlorine filling on the top of water tank while they are still exposure to pollution from aircraft. However, almost of experimental group started working on experimental environment before 30 years-old until the date of examination with chest x-ray. Many evidence-based recommendations advocate against the use of routine chest x-rays for asymptomatic, low-risk outpatients; however, it is unclear how regularly chest x-rays are ordered in primary care. Chest radiography can assist in the diagnosis and management of cardiac and respiratory disease; however, there are many scenarios in which chest x-rays have low value, as the benefits of testing are unclear or offset by the potential for patient harm. For example, the Canadian Association of Radiologists labels the use of routine chest radiography for a periodic health examination (PHE) — a service involving an outpatient with unremarkable history and physical examination — as not indicated because of low clinical value. As primary care physicians are typically responsible for conducting PHEs, the College of Family Physicians of Canada included routine chest x-rays in their top 13 list, for Choosing Wisely Canada, of low-value tests, treatments and procedures that patients and physicians should question.

The limited utility of routine radiographs may be best evidenced by a cohort study of 1282 primary care outpatients who received a chest x-ray despite the absence of thoracic symptoms. The authors found that only 1.2% of chest x-rays detected a major abnormality. Upon further inspection, 93% of these findings were false positives and none required treatment. Because of its trivial diagnostic yield and high false-positive rate, routine chest x-ray for asymptomatic, low-risk outpatients often confers no clinical benefit, while leading to additional unnecessary services (e.g., advanced imaging, procedures and consultations) that can pose additional patient harms and system costs.

Despite extensive evidence against routine chest x-rays for asymptomatic or low-risk outpatients, the frequency with which family physicians are ordering these tests as part of a PHE is unknown. We aimed to quantify the frequency of, and variation in, routine chest x-ray use among health regions, practices and individual physicians in Ontario, Canada. Furthermore, we assessed temporal trends in province-wide use and investigated patient- and provider-level characteristics associated with routine chest x-ray use. Previous literature has suggested that despite low clinical value, routine chest x-ray use for asymptomatic and/or low-risk outpatients in primary care may be quite common. In their review of radiograph reports, Tigges and colleagues found that 34% of chest x-rays ordered were for "routine or screening purposes"; however, this study was limited to a single primary care centre in the United States. Conversely, our study involved a large cohort of patients from multiple regions and practices across Ontario and suggests routine chest x-ray use is uncommon in

Canada. In fact, routine chest x-ray use appears to be appreciably less common than other forms of low-value imaging we have previously studied. Our study underscores the importance of establishing baseline estimates to compare frequency of use across different tests and clinical scenarios, which can provide health care decision-makers with a basis for determining which tests they might preferentially target with quality improvement initiatives aimed at reducing low-value care.

The observed decline in routine chest x-ray use over time may be due to increased recognition among physicians of the limited utility of chest x-rays for screening asymptomatic, low-risk patients, possibly promoted by 2013 *OHIP Schedule of Benefits* revisions that included recommendations against routine chest x-ray reimbursement and new PHE codes to reduce low-value testing. However, it appears the downward trend in chest x-ray use was initiated before the announcement of *OHIP Schedule* changes in November 2012 and their subsequent implementation in January 2013. Further research to identify unmeasured factors that may explain the precipitous drop in chest x-ray use from January–March 2012 to April–June 2012 is warranted.

3.1 Chest X-ray for Screening

Conversely, chest radiographs (CXRs) are one of the most commonly utilized diagnostic tools for chest diseases in clinical practice. The technology is easy to operate and the procedure has a relatively low level of radiation exposure; thus, it is the standard diagnostic tool for respiratory illnesses. Also, it imposes less of a burden on radiologists than other, more sophisticated diagnostic imaging tools.

However, CXRs are not without their shortcomings. CXRs are often performed by personnel that do not specialize in radiology. Therefore, they are more prone to misinterpretation. Of all misdiagnosed lung cancer cases, 90% utilized CXRs and 10% used CTs and other diagnostic tools. Misinterpreting images can result in delayed diagnosis and more negative clinical outcomes. Identifying lesions early while maintaining accuracy is the key to improving lung cancer survival.

Multiple studies have suggested that using CXRs in lung cancer screening may improve survival. For instance, Strauss *et al.* reported findings from randomized controlled trials that show CXR screening can improve lung cancer survival as cancers are diagnosed at earlier stages. Another large population-based cohort study showed an 18% reduction in lung cancer mortality with CXR screening in at-risk populations. Furthermore, a case-control study found that lung cancer mortality was reduced by more than 20% with CXR screening.These studies suggest that CXRs can be significantly beneficial for the screening of lung cancer.

In this study, researcher examine whether retrospective observation of lung cancer patients confirmed by pathology can elucidate significant radiological abnormalities earlier than when diagnoses were made. We also introduce a new comparison method for CXR interpretation in lung cancer patients. We hypothesize that side-by-side comparisons of cropped CXRs will improve abnormal lesion detection.

CXRs were collected from 1,500 lung cancer patients who presented to Uijeongbu St. Mary's Hospital from 2006 to 2016 and whose diagnoses were confirmed by pathology. Excluding patients who were accurately diagnosed upon their first visit and selecting for a wide variety of lesion locations, we compiled radiographs from 50 cases. Cases were selected only from those that presented first to Uijeongbu St. Mary's Hospital without a diagnosis or suspicion of lung cancer. Cases that were transferred from other hospitals were only considered if the lung cancer was an incidental finding; overall, only patients who had initial CXRs not showing lung cancer or those for which cancer was an incidental finding were included. Patients who were diagnosed retrospectively were selected by 2 radiologists, each with 33 years of clinical experience. We also added 5 normal sets of CXRs as controls. These patients were cancer-free for at least 3 years; two were completely normal and 3 developed chronic obstructive pulmonary disease. For research participants, attending physicians who were board certified in pulmonology were recruited from 9 university hospitals in the Republic of Korea. To eliminate bias, no physicians were recruited from Uijeongbu St. Mary's Hospital. The study was approved by the Uijeongbu St. Mary's Hospital Institutional Review Board (#UC17EESI0128). Informed, written consent was obtained from each participant.

For each case, we collected the CXRs obtained until the chest CT that was used to diagnose lung cancer. We selected 6 CXRs with the earliest being a "normal" image, if possible. Subsequent radiographs were selected from those that (I) we suspected showed lesions and (II) were equally spaced chronologically. In cases that had fewer than 5 CXRs that showed lesions, additional earlier CXRs were used as supplements. In cases with more than 6 CXRs, 6 radiographs were selected between when the patient was diagnosed and the last normal CXR, with chronological spacing between the radiographs as equally as possible. Radiographs that were obtained more than 3 years before the next CXR were excluded to minimize potentially severe contrasts. Radiograph selection and confirmation of lesion location with CT were performed by 2 radiologists each with 33 years of clinical experience.

All images, after removal of patient identifiers, were converted to digital files in the jpg format at maximum quality and scaled to 100%. A computer programmer designed the examination program used to evaluate the participants. Images for each case were arranged in chronological order. As in a previously published study, the lesion areas on each image were outlined by freeform outlining using the Adobe Captivate 9 'hot spot' technique (Adobe systems Inc., San Jose, CA, USA). Outlines were made 100% transparent to prevent participants from noticing them. The last image in each case was designated as '0' while other images were designated with numbers that represented the number of days between when those images were taken and when image 0 was taken. If the participant placed the mouse pointer correctly within the outline and clicked, the image's designated number was noted. If the participant clicked in an incorrect area, an 'X' was noted but was not visible to the participant. If the participant thought there were no noticeable lesions on the image, he or she could click a button labeled 'N'. Participants were allowed to click on each image only once.

Participants were allowed to navigate between the slides using arrows on the screen but could not see chronologically later radiographs until they clicked to indicate their designation on the most recent image. This design emulated the conditions used in actual clinical settings, wherein physicians were able to compare recent CXRs with previous ones, but which eliminated the systemic limitations, such as time constraints and other distractors (A). After the reviewing the last image of a case, a slide showed a compilation of the cropped regions of the reviewed images with the lesion. Participants were then asked to identify the image which made them primarily diagnose cancer (DX) and first suspect a lesion (E).The dates of all cases of early detection were measured as that furthest away from the day of actual diagnosis. After recording DX and E, all finalized answers were presented in a portable document format (PDF) file. Lesion diameters, as shown on the CXRs, and the number of days preceding the date of actual diagnosis (F) were recorded. The variables (A, DX, E, F) were compared at each TNM classification of malignant tumors stage using the Wilcoxon rank sum test. Continuous data were reported as mean ± standard deviation, and categorical data as numbers and percentages. Missing data were treated using the Last Observation Carried Forward (LOCF) method.

Further performance comparisons between CXRs showing lesions in ‘hidden’ areas (paraaortic area, paratracheal region, retrocardiac region, subdiaphragmatic region, apices, and hilum area) and in ‘open’ areas (right upper lobe, right middle lobe, right lower lobe, left upper lobe, and left lower lobe) were performed. Also, we examined whether differences in the amount of clinical experience, measured by the number of months the physician was a medical doctor *vs.* a specialized pulmonologist, had an impact on performance. All statistical analyses were conducted by SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) and a P value below 0.05 was considered statistically significant. Data for these comparisons were expressed as means ± standard deviations or as medians with interquartile ranges.

There was study from literature review demonstrated that CXRs can be used to diagnose lung cancer earlier and that a side-by-side comparison of cropped images can enhance lung cancer detection. On average, participants were able to identify lesions 221.72 days before actual diagnoses were made using this approach. All radiographs presented were subject to the same independent analysis as would be expected in real-life situations, with no second opinion from radiologists or patients present to provide additional information. As improved performance was observed with less systemic constraints, it is plausible that better CXR reading can be achieved with improvements to the health care system. Such improvements would allow physicians to evaluate these images with fewer distractions and less time pressure. Additionally, assessing cropped CXRs displayed side-by-side offered further significant improvements, with participants detecting lesions 629.32 days earlier on average. These benefits seemed to exist across different anatomical regions and different lengths of clinical experience. This suggests that the development of software that can display all relevant CXRs side-by-side while allowing physicians to crop them all simultaneously would have significant potential advantages.

These benefits will likely improve lung cancer detection at all levels of clinical practice.

CXRs are used as screening tests for chest diseases as well as other disorders. They have a low cost, can be used conveniently at bedside, have low radiation exposure, and provide an abundance of information that is useful in follow-up studies. Although survival benefits are much higher with LDCT and the advantages of screening with CXRs are still being investigated, the possible merit of CXRs as a screening tool cannot be ignored.

In 2015, 24,267 patients in the Republic of Korea were diagnosed with lung cancer. Among them, 13,366 (55%: 9,868 males and 3,498 females) were aged between 55 and 75 years. A significant portion of the patient population does not meet the indication criteria for annual LDCT screening as it focuses on at-risk and symptomatic patients. Furthermore, financial difficulties, both in developed and underdeveloped countries, as well as patient aversion to radiation exposure can inhibit LDCT utilization. Considering these factors, there is a potential for increased CXR utilization as an alternative screening method.

Notably, with the commencement of the campaign for increased lung cancer awareness, there has been an increase in the utilization of CXR and in the proportion of lung cancer cases diagnosed in the earlier stages (proportion of patients diagnosed with stages I & II lung cancer: before campaign, 26.5% *vs.* during campaign, 35.3%), as well as a reduction in the number of lung cancer cases diagnosed in the later stages (absolute number of patient diagnosed with stage III & IV lung cancer: before campaign, 1,254 *vs.* during campaign, 1,137). Although the correlation between these observations has not yet been proven, it is a plausible conjecture that the increase in CXR screening contributed to this phenomenon. Our study is notable in that it demonstrates that CXRs are a potentially effective tool in lung cancer screening and confirms previous, retrospective findings in a controlled setting. Furthermore, we show that side-by-side comparisons enhanced by purposeful cropping can amplify its benefits. Hence, the addition of a simple feature to existing image viewing software can greatly enhance the ability of physicians to diagnose lung cancer earlier.

It is important to note that, although LDCT screening remains the standard screening method, it has certain shortcomings. Despite adequate LDCT screening, some lung cancers may still be missed. Importantly, the total annual cost between LDCT screening and CXR screening is not significantly different. Thus, because CXR is performed in much larger proportion of cases than LDCT, it is important for physicians and radiologists to accurately read CXRs. Well-organized education in CXR interpretation may improve accuracy.

Approximately 1–4% of radiology reports are misinterpreted. This results in approximately 30% of abnormalities being missed in radiologic examinations. Diagnostic errors can be categorized into missed (no diagnosis made), false (incorrect diagnosis), or delayed (diagnosis delayed although sufficient information was available earlier). Several factors are involved in diagnostic errors. 'Hidden' areas are locations on images where lesions are harder to see due to adjacent or overlapping structures; lesions can also be hard to find due to weak contrast or density. Furthermore, lesions can be missed due to observer fatigue, sleepiness, lack of adequate lighting, or time constraints. To help minimize errors, interpretation conditions or technical factors such as reading room light conditions, viewing distance, and monitor resolution must be improved.

3.2 Chest X-ray sensitivity

Moreover, the sensitivity and accuracy of CXR interpretation can be improved by increased knowledge and experience regarding how to read normal lines, spaces, stripes, and signs on relevant images in comparison to CTs. Errors can be minimized by improving search patterns or paying more attention to blind spot areas. New technologies, such as bone suppression software, dual-energy radiography, and computer-aided design systems are being developed to facilitate more accurate image assessments. It remains to be seen how these changes will help physicians interpret images.

Radiographs must be compared to previous images, consecutively from the least recent to the most recent. In this study, we compared the same regions in CXRs cropped and placed side-by-side, which increased participants' sensitivity to lesion changes. However, such side-by-side, focused comparisons are difficult to achieve in real clinical situations. Further research will be needed to examine the utility of this method. As new technologies such as deep convolutional neural networks that allows automatic CXR comparisons to identify abnormalities have been recently developed, more research will be able to help determine its utility.

Although it is reasonable to assume delayed lung cancer detection will result in progression to higher stages, thereby having a negative impact on prognoses, it is difficult to say with certainty that delayed detection on CXRs has a direct negative impact on outcomes, as demonstrated by related previous studies that examined different patient populations with different methods. For instance, Quekel *et al.* examined cases of non-small cell lung cancer patients with nodular lesions and found that lesions were missed in 19% of the cases. They attributed this to a smaller median diameter of the lesions. The median delay in their study was 472 days, similar to that in our study. It is difficult to examine any changes in the N or M staging because CT was not performed in cases with missed cancer diagnosis. Because of the limitations in their study design, we cannot comment on its impact on cancer prognoses. However, the detection of cancers at smaller sizes with CXRs suggests that CXRs have the potential to play a significant role in the earlier detection of cancers.

Education regarding CXR interpretation is often limited to several hours during medical school. Even during residency and beyond, medical professionals often do not receive specialized training in reading CXRs. This may be attributable to the CXR marginalization with the increased use of CTs. Despite this deficiency, many clinicians make medical decisions based on CXR readings without assistance from radiologists. Therefore, routine education of medical professionals in reading CXRs would be beneficial. All medical professionals must be able to interpret images accurately to maintain quality patient care. Education regarding CXR interpretation is conducted on a routine basis and can be achieved through various methods. However, education is often limited and capabilities between physicians vary, even within the field of pulmonology. All medical professionals, regardless of his or her specialty, should receive a more structured and specialized education on this subject. This study demonstrates that CXRs may have a significant role in earlier lung cancer detection. Also, comparing cropped radiographs side-by-side improves detection, highlighting a potential feature that could be implemented in image viewing programs. Future research is needed to examine whether the application of this method will help with earlier lung cancer detection and outcome. [21] So Chest X-Ray yield good sensitivity for detection.

3.3 Methodology of incompetency architectural design

Example of incompetency architectural design which promote chlorine vaporization in tropical climate. There are few open air chlorine tank with worker over them.

We found passive design of aforementioned building help in promotion of clearing chlorine vapor. Despite of wind promotion, chlorine vapor may still attack worker health. Researcher wish to define if chlorine vapor in this building cause health problem.

Fortunately, there is no adjacent building that may effected from chlorine spreading.

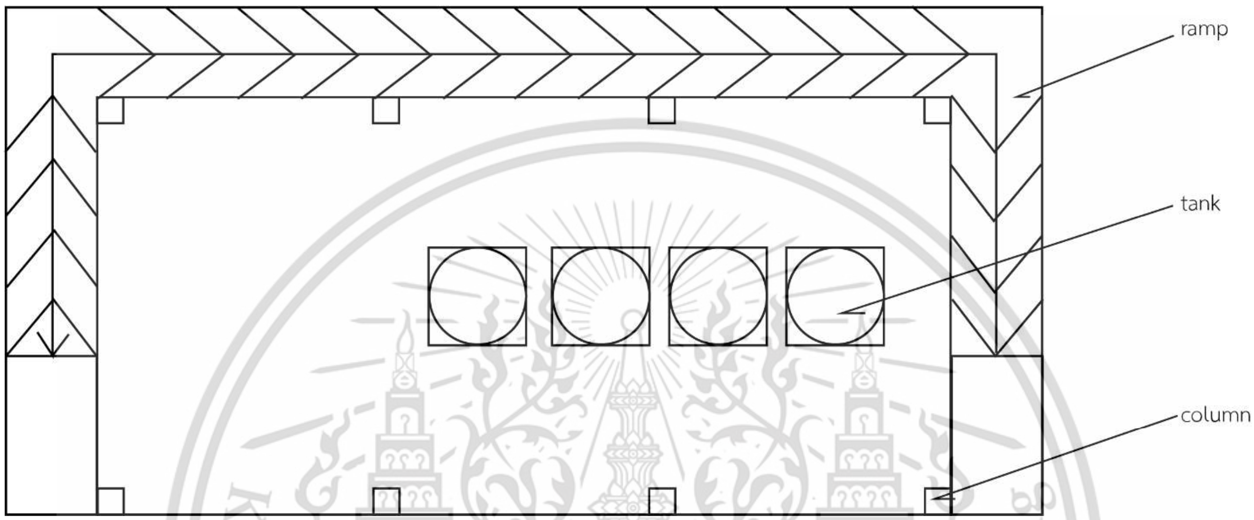

Image 5 : Top view of working floor, 3rd floor of building

Source : Researcher(2023)

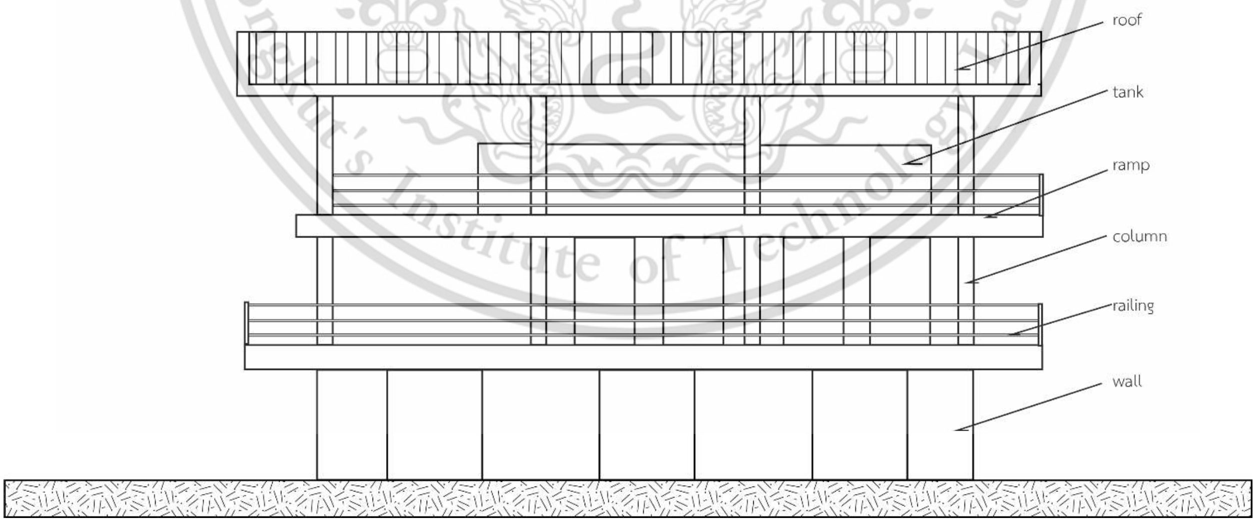

Image 6 : Front view of working floor, 3rd floor of building

Source : Researcher(2023)

Table 1. AIR TEMPERATURE (C)

	J	F	M	A	M	J	J	A	S	O	N	D
Monthly mean max.	30.2	32.3	33.8	34.4	32.7	31.5	30.7	30.2	29.9	29.9	30	29.5
Monthly mean min.	18.8	20.5	23.4	25.2	25.2	25	24.5	24.2	23.7	22.8	21.4	19.3
Monthly mean range	11.4	11.8	10.4	9.2	7.5	6.5	6.3	6	6.2	7.1	8.6	10.2

	Highest / Lowest	AMT / AMR
Highest / AMT	34.4	26.6
Lowest / AMR	18.8	8.4

Table 2. HUMIDITY, RAIN AND WIND

RH (Percentage)	J	F	M	A	M	J	J	A	S	O	N	D
Monthly mean max. am.	75	85	75	83	90	98	95	92	95	95	80	85
Monthly mean min. pm.	55	55	55	58	62	62	72	72	82	73	66	61
Average	65	70	65	70.5	80	80	83.5	82	88.5	84	73	73
Humidity group	3	3	3	4	4	4	4	4	4	4	4	4
Rainfall (mm.)	5	12	40	86	191	206	247	282	280	123	34	7
Wind: Prevailing	NE	NE	SE	S	S	SW	SW	S	SE	NE	NE	NE
Secondary												

Total

Total
1513

Table 3. DIAGNOSIS

		J	F	M	A	M	J	J	A	S	O	N	D
Humidity group		3	3	3	4	4	4	4	4	4	4	4	4
Temperature (C)													
Monthly mean max.		30.2	32.3	33.8	34.4	32.7	31.5	30.7	30.2	29.9	29.9	30	29.5
Day comfort	Max.	29	29	29	27	27	27	27	27	27	27	27	27
	Min.	23	23	23	22	22	22	22	22	22	22	22	22
Monthly mean min.		18.8	20.5	23.4	25.2	25.2	25	24.5	24.2	23.7	22.8	21.4	19.3
Night comfort	Max.	23	23	23	21	21	21	21	21	21	21	21	21
	Min.	17	17	17	17	17	17	17	17	17	17	17	17
Thermal Stress													
	Day	H	H	H	H	H	H	H	H	H	H	H	H
	Night			H	H	H	H	H	H	H	H	H	

Table 4. DESIGN	
Layout	East-West orientation
Spacing	Single banked room
Air movement	Open spacing for breeze penetration
Opening	Internal opening
Wall and floors	Heavy material
Roof	Light roof with insulator
Outdoor sleeping	No
Rain protection	Protect heavy rain in north-south
Opening character	Opening size 20-40%
Opening position	Opening at north-south
Opening protection	Rain protection at door
Roof character	Light roof and reflection
External protection	Rain water drainage

Table [1] : Mahoney Table of Ubon Ratchathani Province

3.4 Chest X-ray Technique and Measurements

Radiography has always been one of the most ubiquitous diagnostic imaging modalities so far, while chest X-ray (CXR) is the most commonly performed diagnostic X-ray examination. CXRs has an important role in clinical practice, effectively assisting radiologists to detect pathologies related to the airways, pulmonary parenchyma, vessels, mediastinum, heart, pleura and chest wall. In recent years, great advances in GPU computing and research in the fields of machine learning have led to the trend of automating CXR image diagnostic and many other X-ray modalities. In addition, the availability of large-scale public dataset has sparked interest in study and application, with some of them already being used and integrated into the Computer-Aided Diagnosis (CAD) system to reduce the rate of CXR misdiagnosis.

The reports of CXR were collected in the three hospitals to determine the findings of CXR. These findings were categorised into six groups (the first four groups were considered clinically relevant abnormalities) The primary outcome measure for our study was the proportion of patients in whom there was a change in patient management by the GP following CXR. This proportion and the corresponding 95% confidence interval (CI) were calculated using the statistical program Confidence Interval Analysis.

All patient were performed chest x-ray and measured cardiothoracic ratio(CT ratio) and descending branch of right pulmonary arteries. Certified radiologist measured and recorded the means of data.[22] Diameter of descending branch of right pulmonary artery may refer to pulmonary hypertension if diameter is higher than 1.6centimeter.

Chest radiographs can be normal, or they can sometimes show diffuse nodular opacities,patchy consolidation, pulmonary edema, and signs of vascular congestion. Radiographic abnormalities may appear late as lung injury develops and progresses. Persistent hyperreactivity and airflow obstruction may manifest radiographically as air trapping . The role of CT in evaluating lung injury is not established. CT paired inspiratory and expiratory thin-section techniques may be used to evaluate patients with chronic pulmonary dysfunction after chlorine exposure.Current understanding of the toxicity of chlorine inhalation in humans primarily comes from experience during and immediately after World War I as well as from industrial accidents. Exposure from household chemicals and at swimming pools is also wellknown. Depending on the concentration and duration of chlorine exposure, toxicitycan range from irritation of the upper aerodigestive tract epithelium to diffuse lung injury and hemorrhagic necrosis leading to death.

The mechanism by which chlorine gas injures the respiratory tract epithelium is related toitsability to form hydrochloric and hypochlorous acids in the respiratory tree. Because of itsrelatively low solubility in water, chlorine canreach the periphery of the lungs and cause extensive damage, unlike highly soluble gasses,such as ammonia, that are removed from theproximal airway by mucociliary clearance.Injury begins with edema of the upper air-way and lung parenchyma, followed by development of a cellular exudate in the alveoli.As injury progresses, severe edema, hemorrhage, and destruction of the bronchiolar mucosa can develop. After data gathering, raw data would be analysed with statistical technique with SPSS software. Using the t-test for analysis of means of each recorded data with 95% confidence interval were calculated. The analysis determined the statistically significant variables ($p<0.05$) to model the probability of a relationship between each data.

3.5 Sample size

Using Cohen's(1992) Interpreting for effect size value[23], we chose the medium effect size r=0.3, then calculated sample size with Type I acceptable error(α) = 0.05 and Type II acceptable error(β) = 0.2

H0: *Rho*=r0 = 0(Correlation coefficient)

H1: *Rho*=r1 = 0.3(Expected correlation coefficient - medium size)

n= sample size

$$Z_{(r_0)} = \frac{1}{2}\ln\left(\frac{1+r_0}{1-r_0}\right) \quad Z_{(r_1)} = \frac{1}{2}\ln\left(\frac{1+r_1}{1-r_1}\right) \quad n = \left(\frac{Z_\alpha + Z_\beta}{Z_{(r_0)} - Z_{(r_1)}}\right)^2 + 3$$

After using mentioned value, the resulting sample size(n) is equal to 85 while total n in this study is 103.

Almost researchers typically use Cohen's guidelines of Pearson's *r* = .10, .30, and .50, and Cohen's *d* = 0.20, 0.50, and 0.80 to interpret observed effect sizes as small, medium, or large, respectively. However, these guidelines were not based on quantitative estimates and are only recommended if field-specific estimates are unknown. This study investigated the distribution of effect sizes in both individual differences research and group differences research to provide estimates of effect sizes in the field.[22]

Posterior - Anterior (PA) CXR. This is the most common and preferred type of chest X-Ray. Posterior - anterior refers to the direction of the X-Ray beam travel.; i e. X-Ray beams hit the posterior part of the chest before the anterior part. To obtain the image, the patient is asked to stand with their chest against the film, to hold their arms up or to the sides and roll their shoulders forward. The X-ray technician may then ask the patient to take few deep breaths and hold it for a couple of seconds. This techniques of holding the breath generally helps to get a clear picture of the heart and lungs on the image.

Statistical Analysis

The mean, standard deviation and median were evaluated for the distribution of the quantitative value. Correlation coefficient was used to evaluate correlation between each parameter with the threshold of higher than 0.25 of being significant. T-test were used to evaluate relationship between experimental and controlled group with 95% confidence interval. The analysis determined the statistically significant variables ($p<0.05$) to model the probability of relation of increasing age compared to cardiac size and diameter of descending branch of right pulmonary artery which may imply to be pulmonary hypertension.

Chapter 4

Experimental Results

Researcher has measured means PM2.5 of whole year in experimental building which showed higher values than other area in same district which could be effected from aircraft pollution. Means temperature of whole year, about 33 degree Celsius during working hour, was measured at top of chlorine tank which worker need to stay there for working under risk of exposure to chlorine vapor under hot climate.

At the first glance, data of diaphragmatic difference showed wide range of distribution while there may be no statistical difference of cardiothoracic ratio between controlled and experimental group. There are slightly higher of means in age in experimental group compared with controlled group.

When focusing on the correlation of coefficient, we observed some correlations between age with diameter of descending branch of right pulmonary artery. Age was separated into 4 groups prior using SPSS for analysis in Table[2], first is less than 25 years-old, second group is 25 until less than 35 years-old, third group is 35 until less than 45 years-old and last group is 45 years-old and higher. However, there is no significant correlation between age with CT ratio. The expression of difference in correlation coefficient is higher than 0.25 while p value shall be lower than 0.05.

Table[2] Means of each parameter

Data	Group	Means	SD	Std.Error Mean
Age	Control group	26.33	8.84	1.357
	Experimental group	38.98	9.77	2.117
CT ratio	Control group	0.45	0.05	0.007
	Experimental group	0.42	0.04	0.011
Descending branch of right PA (cm)	Control group	1.28	0.19	0.040
	Experimental group	1.48	0.21	0.033

Table[3] Test of Normality distribution

(Sig. showed lower bound of true significance)

Data	Statistic	df	Sig.*
CT ratios (control)	0.090	52	0.2
CT ratios (case)	0.089	51	0.2
Descending branch of the right PA (control)	0.067	52	0.2
Descending branch of the right PA (case)	0.088	51	0.2

Table[4] T-test of 95% confidence interval (no aging relation)

T-test	Value	Sig.	t	df	95% confidence interval of difference (t-test)	
					Lower limit	Upper limit
CT ratios (t-test)	0.000	0.294	3.556	101	0.014	0.049
Descending branch of the right PA (t-test)	0.000	0.186	-4.868	101	-0.276	-0.116

Table[5] Relationship of data using age as independent factor

Correlations			Age
Spearman's rho	CT ratio	Correlation Coefficient	0.043
		Sig. (2-tailed)	0.663
	Descending branch of right PA	Correlation Coefficient	0.276
		Sig. (2-tailed)	0.005

Chapter 5 Summary and Discussion

5.1 Summary

At first, we expected all parameter correlates with the exposure to air pollution. Although of descending branch of right pulmonary artery demonstrated significant correlation, the result showed no relationship with age-CT ratio.

As we previously knew, air pollution such as nvPM from aircraft business and evaporation of chlorine under poor architectural design with hot climate may damage lungs. We separated age group and this study showed significant increase of diameter of descending branch of right pulmonary artery as compared to unexposed controlled group, but no significant of CT ratio was found.

5.2 Discussion

To correct building design, researcher advise to put more temperature control system. Building should not allow high temperature at the room of chlorine water mixing. Moreover, shielding shall be placed on water tank opening to decrease chlorine vapor spreading into the room where worker stay.

In conclusion, working in incompetent architectural design in a tropical climate in this study which are no temperature control, no evaporation control and exposure of worker during chlorine filling on the top of water tank supported hypothesis of almost change in cardiovascular and respiratory system under chest x-ray but almost of controlled group was quite younger than experimental group which could be the cause of error. However, more research may need to be performed to identified the exact cause of abnormality in chest x-ray.

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