Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

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To cite this article: S F Z Bakri *et al* 2019 *J. Phys.: Conf. Ser.* **1150** 012001

Metal fumes toxicity and its association with lung health problems among welders in automotive industry

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Abstract. Welding is one of the fundamental processes and considered the world's most vital trades especially in metal industries. Along with mechanization and automation growth in the welding process, there is increasing concern over occupational lung disease among welders due to exposure towards welding fumes in a body shop area of automotive industries. This paper reviews previous studies on the implications of metal-rich contained in automotive welding fumes to lung disease risk among welders. In total, 123 publications for original papers, review articles and statements published in PubMed, Scopus and Science Direct that were relevant to research on lung diseases associated with metal-rich element contained in welding fumes are cited in this review article from 1950 to 2016. The presence of a specific heavy metal emitted in the automotive industrial joining process and the risk of lung disease are discussed systematically. These findings suggest that further studies on interactions of hexavalent chromium, nickel, iron, cadmium, aluminium and beryllium from welding fumes and induction of lung disease in automotive industries are highly warranted.

1. Introduction

Welding is one of the fundamental processes for joining metals in metal industry. Thus, this joining process is commonly preferred than any other joining techniques such as glue bonding, nailing or riveting that required additional costs especially in consumables for each joint [1]. Along with mechanization and automation growth in the welding process, there is increasing concern over occupational lung disease among welders due to exposure towards welding fumes in a body shop area of automotive industries. The complex mixture composition of different metals in welding fumes and rate of fumes generation depends on the material of the welded metal, types of filler, coatings, technique and skill of welder [2]. Despite the fact, the adverse health effects of welding derived from radiation, electrical energy, heat, noise, vibration and chemical hazards; the generated particulates and gases during welding are considered to be the most unsafe exposure compared with other welding's by-products [3]. By right, absorption, distribution, metabolism and excretion are the main factors that influence metal toxicity especially welding fumes in the human body.

Welding is often associated with respiratory symptoms since inhalation is a common route of exposure to a welder [4]. Nowadays, in a fast-growing global industrial era, occupational and environmental lung disease persists and considered as major causes of respiratory problems [5]. Heavy metals exist in welding fumes is predominantly a significant potential threat to human health generated from occupational. Studies by El-Zein *et. al* [6] have revealed that a number of welders reported

experiencing one of the welding related symptoms such as chest tightness, wheezing, coughing or other respiratory symptoms whereas about half of welders experienced at least three of systemic symptoms (i.e. flu-like symptoms, aches and pains, throat, digestive, taste and fatigue) while welding. The post lung impact subsequently from toxic inhalation can lead either local or systemic effect after exposure which local effects occur at the body part that was exposed to the substance and this result in irritation of respiratory tract (i.e sneezing). Meanwhile, a substance that absorbs into the bloodstream and deposited into other organs and causes effects in one or two target organ is known as systemic effects. Metal fumes particularly beryllium, cadmium, mercury, nickel, zinc and chromium is one of the causes of systemic toxicity and this toxic-particle contribution are influenced by particle size as a principal contributor, shape and density [7]. According to Frank [8], occupational lung disease is one of the problems commonly occurred among workers due to workplace exposures. In 2013, Antonini et. al [9] published a paper in which they observed the particles from welding fumes had deposited in lung interstitial areas in rat lung tissues samples and concluded that the deposition of particles in the lungs for both workers and animals was depending on the type of fume which can persist for a significant period of time. Supplementary to that, the analysis shows that the pulmonary function values may decrease along with the increase of work duration and the response is either acute (adverse effect was seen soon after one-time exposure to substance) or chronic toxicity (results from long-term exposure to lower dose of substance) [4], [10], [11]. Moreover, exposure to metal fumes increased the susceptibility to infectious pneumonia especially lobar pneumonia and this effect is not limited to the fatal case and the risk depends on the cessation of occupational exposure [12]. A high exposure to welding fume in a long-term of the period may cause a macrophage proliferation in the alveoli, airways and interstitium and this associated with pulmonary fibrosis and produce differential acute lung toxicity [13]–[15].

From the past research, the findings suggest that in general there is a strong link between metal fumes generated from welding with lung deterioration. Therefore, in assessing the relation of risk exposure with a greater accuracy, relevant biomarkers should be established to enable the control of exposure were set in the safe and right level of exposure [12]. This paper review on the adverse health impact to respiratory systems due to prolong exposure towards metal fumes emits from welding process in the body shop. The impacts of welding fumes on lung and metal-rich elements contained in automotive welding fumes were discussed in this study. The overall study of specific metal-contained in welding fumes and its capability to initiate a lung disease in the automotive industry is crucially needed to give a clear picture and direction for a future innovation and exploration especially in the scope of occupational health and industrial hygiene.

2. Search strategy and study selection

This review of the world literature on heavy metal concentration among welders and its impact on worker's lung included a search of the online electronic databases published in the English language in PubMed and Science Direct. The relevant bibliographies in the identified paper were also taken into considerations and these efforts were not limited to put into use of Google and reference manager programme as further confirmatory search tools. The literatures searched in the reference manager were published from 1950 to 2016 and these were focused on the series of the development of lung deterioration due to metal fumes exposure from welding process only. Each database was searched from September to December 2016. General keywords used to make the full review more focused in the search are a metal fume, heavy metal, welding fume, lung disease, pulmonary, metal inhalation, auto-worker, automotive, automobile, welder, stainless steel, mild steel, exposure to metal, health risk, and metal toxicity. In obtaining a specific focused on the existence of metals in the automotive welding fumes and its association with impact to welder's lung, the search has been made through journal database of Scopus, Science Direct and PubMed only by using term "heavy metal AND welder AND lung AND automotive" within the year 2009 to 2016. The selection criterion only focuses on the inhalation as the route of exposure. There were nine relevant research publications were retrieved and selected from Scopus, Science Direct and PubMed. The validity and strength of each study were

determined based on a qualitative assessment of study objectives, methods and population. In total, 123 publications for original papers, review articles and statements relevant to research on lung diseases associated with metal-rich element contained in welding fumes are cited in this review article.

3. Metal fumes generated from welding processes

There are emerging concerns among occupational health practitioners to speak out on the potential health impacts associated with exposure to metal fumes among welders. Despite its safety and efficacy, welder suffers from several major drawbacks: respiratory systems, radiant energy, hearing impairment and neurological behaviour [16]–[21]. Around the late 1950s, small-scale research and case studies began to emerge linking between heavy metals and lung problems among welders [22]. In a study conducted by Antonini [3], it was shown that the actual dose of air particulates concentrations emitted and penetrated into lungs during welding is a crucial factor in evaluating welder's health conditions since the studies marked a divergence concentration of contaminants in welders surrounding air. Forty years later, Coggon et. al [23] concluded there is strongly linked to lobar pneumonia and welder's health.

A finding on the presence of lung problems among welders worldwide due to exposure to metal fumes has been presented in Table 1. The results show that there was a correlation of heavy metal in welding fumes with the fitness of lungs among workers especially welder and this may contribute an information to a further investigation of the impact of metal fumes towards welder's pulmonary systems. There is a great variation between different groups of the welder, thus it is suggested that welder cannot be studied as one group. This is for the reason that the exposure varied among welders that rely on environmental (welding method and material used) and individual factors like work habit and pulmonary ventilation rate [24]. On the question of the existence of metal in welder's lungs, the study executed by Dufresne [25] stated that the metal-rich fine particles of aluminium, nickel, manganese, cadmium and chromium were found deposited in the lung. The studies presented thus far provide evidence that the metals may penetrate into a deeper portion in the bronchiolar and alveolar of the lungs when the metal particles are less than 0.5µm while other authors point out the particles less than 5 µm [26]–[28]. The finding observed is contradicted by Hallock et. al [29] that stated the particles less than 10 µm may reach to the alveolar region in the lungs once inhales. A clear respiratory physiology and physiochemical principles and the mechanism was explained by Miller and Chang [7] in their articles specified that an aerodynamic particles greater than 10 µm are deposited on the larynx or stuck in the nasopharynx; 3 µm to 10 µm in size deposited in conducting airways; 0.5 µm to 3 µm penetrate deeper to distal airways and alveoli space; and particulates less than 0.5 µm will behave like a gas and exhaled out.

In 2010, Balkhyour and Goknil [30] have listed aluminium, cadmium oxides, copper, iron oxide, manganese, nickel, zinc oxides, beryllium, chromium, fluoride, lead, molybdenum and vanadium as the common types of metal existed in welding fume and a few of the metal was supported by [31]. Furthermore, beryllium, cadmium, arsenic, hexavalent chromium compounds and nickels compounds have been classified as carcinogenic metal agents by International Agency For Research On Cancer (IARC) due to the occupational exposure that caused lung cancer with sufficient evidence in humans [32]–[34]. In 2017, IARC had revised and updated the welding fumes is listed under Group 1, which classified as carcinogenic to humans [35]. Concurrently, iron is a pre-dominant metals element in welding fume where 90% was emitted by mass in shielded metal arc welding (SMAW) followed by most abundant metals in SMAW, gas metal arc welding (GMAW) and gas tungsten arc welding (GTAW): manganese, zinc, chromium, aluminium and copper [36]–[38].

Table 1. Research studies on metal fumes generated from the welding process.

Year	Trace Metal	Research Findings	Ref.
2014	Fe (82.8%); Mn (15.2%); Cu (1.84%); Al (0.17%) generated from GMA-MS. Fe (57.2%); Cr (20.3%); Mn (13.8%)	GMA-SS[a] and GMA-MS[b] have similar cytotoxic features and the metal constituents of Cr (IV) *in vivo* studies	[39]

	Ni (8.51%); Cu (0.16%); Al (20.7%) generated from GMA-SS.	appear to influences the toxic response to pulmonary systems.	
2010	47 cases Cr (IV); 35 cases Ni, 12 cases welding fume; 8 cases of cadmium; and 1 case of arsenic exposure.	A case study conducted in 2006 – 2009 in Korea shows that 3,353 patients of definite and probable occupational lung cancer are caused by exposure to an occupational carcinogen.	[40]
2009	Zn, Cu, Ni, Pb and Fe generated from spot weld.	The metal traced is lower than standards set by ACGIH[d] TLV[e].	[41]
2006	Al generated from MIG[c]	A correlation between ambient total dust concentration with aluminium concentration in urine and plasma from 1999 to 2003 have been traced and recorded. Aluminium-containing particles deposited in lungs after inhalation was eliminated for a long time due to slow resorption.	[42]
1993	Cd (0.096 µg/m^3); Cr (4.9 µg/m^3); Ni (3.05 µg/m^3); Pb (1.37 µg/m^3); Cu (82.4 µg/m^3); Mn (425 µg/m^3); Fe (2265 µg/m^3) generated from GMA-SS.	The composition and quantity of chromium and nickel were found highly in arc welded stainless steel.	[26]

[a] Gas metal arc welding (mild steel electrode).
[b] Gas metal arc welding (stainless steel electrode).
[c] Metal inert gas.
[d] American Conference of Governmental Industrial Hygienists.
[e] threshold limit value.

Table 2. Research findings on the association of welding fumes and lungs among welder in automotive industries.

Study Design	Trace Element	Study Findings	Ref.
Population Study	Not reported	Number concentration is 3.0 x 10^5 part cm^{-3} (15 times higher than background level) whilst lung deposition surface area concentration that was inhaled by TIG[f] welder is 1.3 x 10^4 µm^2 cm^{-3}. The personal sampling needs to conduct together with stationary measurement in order to minimize underestimate of concentrations.	[43]
Experimental Group	Fe, Cr, Mn, Al, Si and Ni.	Pulmonary siderophages, lung fibrotic lesion and other respiratory lesions were diagnosed and significantly higher among welders. Iron is the major element recorded among arc welder.	[13]
Pilot Study	Al, Cr, Mn, Fe, Cu, As,	Al, Cr, As, is slightly higher in weld bonding fumes and apparently the percentage of abnormal pulmonary function test results were higher compared to spot weld welders.	[44]
Comparative study.	Fe, Cr and Ni.	The lung samples diagnosed from death welder reveal that the subject suffered a pulmonary fibrosis based on the presence of small right lung nodule and scarring at left major fissure and lingula. The existence of iron, chromium, and nickel was found in the human lung samples.	[9]
Meta-analysis	Not reported	High variability of surface area concentration in manual resistance, automated resistance and GMAW[g]. Mean number	[45]

		of concentration equal to 1.0 x 10^5 part cm^{-3}. Average lung deposited number concentration is 2.5 x 10^3 μm^2 cm^{-3} (range from 49 to 3200 μm^2 cm^{-3}).	
Meta-analysis	Plant A: Fe and Mn Plant B: Fe, Mn, Zn, Cu, Co and V.	Number concentration from MAG[h], MIG[i] in Plant A and spot welding in Plant B is 7.8 x 10^4 part cm^{-3} and 6.4 x 10^4 part cm^{-3}. A distribution of particle size and types of metal emitted from work area is varied and this characteristic causes a differing area of metal accumulation in the respiratory tract.	[46]
Cohort Study	Co, Cr, Ni, Fe, Mn, Al, Pb.	A number of study participants with exposure to metal agent prominently aluminium, lead, chromium, iron, cobalt, manganese and nickel thru inhalation from high-grade steel welding has a disagreement percentage. Nickel and manganese recorded high exposures in high-alloy steel compared to other metals.	[47]
Cohort Study	Not reported	[j] FEV_1/FVC[k] and $FEF_{25-75\%}$[l] compared to new welders. In overall, the results demonstrated low readings among welder in mean FVC, FEV_1, FEV_1/FVC and PEFR[m] and this associated with chronic bronchitis after adjusting for cigarette smoking.	[10]
Cross-sectional study	Zn, Cu, Ni, Pb and Fe.	The metal traced is lower than standards set by ACGIH TLV. Results of respiratory symptoms, for instance, sputum and dyspnoea have raised significantly among spot welder.	[41]

[f] tungsten inert gas.
[g] gas metal arc welding.
[h] MAG = metal active gas.
[i] MIG = metal inert gas.
[j] FEV_1 = forced expiratory volume in one second.
[k] FVC = forced vital capacity.
[l] $FEF_{25-75\%}$ = forced expiratory flow at 25-75% of the pulmonary volume.
[m] PEFR = peak expiratory flow rate.

4. Exposure by task: mild steel and stainless steel welding

In the late 1990s, Moulin et. al [48] showed that the highest standardised mortality ratio (SMR) for lung cancer was among mild steel welders compared to the lowest values among stainless steel welders and those predominantly exposed to hexavalent chromium. However, there is an inconsistency with this argument. This interpretation contrast with Sjögren et. al [49] results that by taking into account of smoking habits and asbestos exposure, there is a clear connection between stainless steel welding fumes and the episode of lung cancer. The results were consistent with those of other studies and suggest that the generating of specific metal in welding fumes notably in stainless steel induced more pulmonary issues contrary to mild steel [50]. This results may be explained by the fact that iron is the predominant element in mild steel followed by manganese with 80% to 90% of Fe and 1% to 15% of Mn; however, these metals are significantly low in stainless steel welding, as chromium and nickel are a potent toxic metal emitted from welding fumes with 15% to 30% of Cr and 5% to 10% of Ni respectively [3], [17], [51]–[54]. It seems possible that these results are also due to the high particles mass and number concentration that was generated by stainless steel welding, as the consumption of rod number is greater than in mild steel welding [55].

Overall, stainless steel welding is more hazardous compared to mild steel welding as it contained a considerable amount of nickel and hexavalent chromium [56]. Nevertheless, welding fumes discharged from both mild steel and stainless steel had obviously promoted the risk of lung

cancer to worker especially in welders, yet still, the evidence showed that the response of pulmonary inflammatory was obviously increasing in the stainless steel fumes [57], [58]. On the other hand, some researchers found that the increased of lung cancer risk among welders was not due to confounders; smoking habit or asbestos exposure [44], [59]. The research would have been more relevant if a wider range of the differences in severity of exposure to welding fumes, duration of exposure, welding in confined space and use of protective equipment, use of control measures together with smoking habits had been explored and may explain the apparent inconsistency [60], [61]. There are several possible explanations for this result. Tobacco has the extensive role in influencing the progress of lung cancer; yet, the existing evidence of lung cancer in family history and other carcinogen-chemical exposure factors within occupational setting can trigger the development of lung cancer among smokers and non-smokers [62]–[66]. Apparently, the finding is consistent with Milatou-Smith et. al [67] and reveals a significant exposure-response relationship between stainless steel welding and lung cancer notably when exposed to high levels of chromium that existed in stainless steel welding [49], [68], [69]. The persistence of stainless steel welding fume in the lungs is longer than mild steel welding fumes and this develops a pneumotoxic effect as the fume contained two highly cytotoxic metals that were not presented in mild steel fume: chromium and nickel [70], [71]. The investigation on the toxicity of derived metals in welding fumes that were carried on animal had shown and confirmed the similarity as in cells treated with serum-contained media and this support the ideas of metal fumes as mediating factor of pro-inflammatory responses in alveolar epithelial cells [72]. Therefore, this had a potential mechanism to lead adverse health effects to welders. These findings further support the idea of the development of pulmonary edema, acute respiratory distress symptoms (ARDS) among adults or infection to pulmonary systems due to stimulation and exposure of metal-rich in welding fumes notably cadmium [73]. These results are consistent with those of other studies and suggest that there is a number of metal in welding fumes that have been recognized as the root of respiratory problems [74]. Another study compared on the readings of Swedish seven different plant and impact of occupational setting to respiratory systems had found that the deposited particles mass concentration in alveolar region and head airways are 20% and 70% respectively [46].

5. Heavy metals in welding fumes and lung issues in automotive industry

The automotive industry is one of industrial sector with a high prevalence of welding process that was performed in the body shop area with a daily basis emission exposure to workers. There have been a number of studies on health impact among auto workers in the automotive industry specifically on the risk of lung cancer associated with asbestosis exposure; bladder cancer; colorectal cancer; digestive track issues; squamous cell carcinoma; and liver cancer [75]–[84]. So far, however, there has been little discussion about the impact towards lung function among automotive welders due to welding fume exposure. According to the NIOSH [85], the symptoms and target organs of welding fumes are varied and may affect eyes, skin, respiratory systems and central nervous system. It has been concluded in previous research-reviews that the complication of pulmonary from welding fumes inclusive the arising of siderosis, chronic bronchitis, chemical pneumonitis, changes of lung function, pneumoconiosis, asthma, airway irritation, lung cancer and metal fume fever [86]–[91]. In observing the accumulation of metals particularly ultrafine particles into lungs, Table 2 shows the correlation of lung disease in automotive welder with metal emitted from welding fumes. The number concentration (part cm^{-3}) and surface area or lung deposited surface area (μm^2 cm^{-3}) were included as the authors claimed that these approaches are a useful metrics in forecasting any impact and or deterioration of pulmonary systems [92]. Unfortunately, there are a limited data and research available on the lung deposited surface area [43].

In another major study conducted in 2003 to 2004, Fernández-Nieto et. al [93] points that there is 12.4% of respiratory-work related illness at Spain associates with sick leave taken due to exposure towards chemical agents notably cadmium, manganese, chromium, nickel, aluminium and arsenic. Although arsenic is classified under metalloid elements and not a metal, yet, the influence toxicity and ionic characteristics need to put into consideration and discussion [94]. In 2010, Grass et. al [95] published a paper in which they described those ultrafine particles in welding fumes enriched in iron, manganese and chromium, hence, the exposures are in higher concentrations. The present findings

seem to be consistent with other research which found that beryllium, zinc, iron, cadmium, arsenic, chromium and nickel are associated with lung disease as target organ systems [96]. However, the results from other authors suggested that there is an association between lung impairment with the predominant metal-rich emission from welding fumes specifically iron, chromium, nickel and manganese as these metal strongly lead to adverse health effects [51], [53], [97]. Apart from that, Christensen [98] listed other metal of arsenic, cadmium, and lead as toxic metals representatives. Therefore, the findings are discussed based on the research of common list metal-caused pulmonary disease from automotive welding fume exposure.

Further analysis by Siemiatycki et. al [66] showed that aluminium production, arsenic and arsenic compounds, beryllium, cadmium and cadmium compounds, chromium compounds (hexavalent), selected nickel compounds and iron has a strong evidence of lung caused disease in an occupational setting. Contrary to expectations, the study conducted by Antonini [99] found that the freshly generated metal fumes from welding process had given a large impact of lung inflammation than aged fumes. This result may be explained by the fact that the higher concentration of reactive oxygen species (ROS) was presented on the surface of this freshly generated fumes. The previous *in vivo* and *in vitro* studies conducted in both human and animal and a pulmonary deterioration arises from welding fumes exposure was simplified in Table 3. A greater focus on six elements of metal in welding fumes could produce interesting findings that account more for a significant lung-caused-disease. Specifically, the following issues will be focused on chromium, nickel, iron, beryllium, aluminium and cadmium.

Table 3. *In vivo* and *in vitro* experiment in human and animal on lung disease trigger from welding metal-rich exposure.

Metals	Organ Site (IARC)	Study Findings	Ref
Cr	Lung	Experimental study on male A/J mice shows that hexavalent chromium initiates a lung tumour and this research indicates that there is a potential tumour promotion in welder's population.	[100]
		A condensed vapour of hexavalent chromium showed a significant irritation in respiratory systems and was linked to occupational asthma due to cytotoxic response to human lungs.	[101]
		A study on the prolonged accumulation of hexavalent chromium in the lungs that were conducted in human and animal had disclosed a significant cancer hazard notably lung cancer.	[102] [103]
		Chromium may excrete from the body as waste yet still accumulate in the welder's lungs.	[104]
		Chromium in metal fumes has been proven to induce injury and lung inflammation and results obtained indicated that a single exposure towards chromate leads to acute inflammatory response and trigger pneumonitis of the lung.	[105]
Ni	Lung	A sensitizing agent of occupational asthma.	[96]
	Nasal cavity and paranasal sinus	Nickel has been identified as a significant contributor to a lung disease and the exposure is slightly higher in stainless steel welder.	[106]
		Nickel is the common metal found in welding fumes and a large amount of nickel exposure promotes injury and inflammation of lung including pneumonia.	[107]
		The findings clearly showed that all by-product of nickel able to cause nasal and lung disease.	[108]
		Nickel fumes may induce the formation of a lung tumour, systemic toxicity and immune dysfunction. These lead to lung injury and serious inflammation.	[70]
Fe	Lung	Respirable particles of iron notably iron oxide that generated from welding process and accumulated in the pulmonary may cause a benign	[109] –

		pneumoconiosis, siderosis and silicosiderosis (combination of iron and silica) that associates with pulmonary fibrosis.	[114]
		Deposition of iron particles from arc welding in the lungs resembles silicosis.	[115]
		A higher risk of pneumonia was related to exposure to iron in metal fumes.	[12]
		A prolonged exposure to iron-rich metal in spot welding particles had irritated lung areas and thus contributes to systemic and local inflammatory effects.	[116]
Al	Lung Urinary Bladder	The lung disease associated with exposure to aluminium has been reported in 2003 and 2004 with one and three cases respectively.	[93]
		There is a significant decrease in lung function among welder that was used MIG welding of aluminium as the fumes contained 51.4% of aluminium. The decreased was affected in Peak Expiratory Flow (PEF)[n] and 75% of Mean Expiratory Flow ($MEF_{75\%}$)[o] in one week of exposure.	[117]
		An effect of pulmonary disease produced by an exposure to aluminium fumes by welding process is differing than exposure to aluminium dust.	[118]
		The aerosolized aluminium fume produced during aluminium arc welding may induce pneumoconiosis in welder especially in the limited area of ventilation.	[119]
Cd	Lung	Cadmium in welding fumes eventually lead to abnormal chest radiograph and this includes acute lung injury and occupational asthma.	[96]
		Recognized as causes of emphysema since the 1950s.	[120]
		Cadmium oxide trigger pneumonitis, metal fumes fever and lung injury via acute inhalation.	[3] [73] [91]
Be	Lung	Exposures to beryllium can result in three types of lung diseases namely acute pneumonitis, chronic beryllium disease (granulomas and fibrosis in the lungs) and lung cancer.	[96]
		A granulomatous inflammatory disorder or known as chronic beryllium disease commonly occurred due to the existence of beryllium at the workplace emitted from work process. It is identical to sarcoidosis and usually affected lung area.	[90]
		Chemical pneumonia was caused by beryllium oxides and the people exposed to the beryllium factories were diagnosed sarcoidosis.	[121]
		As the beryllium reacts as a potent carcinogen to animals, therefore, the impact of lung cancer among workers exposed to this element is expected.	[122]
		A long latent exposure period of beryllium that associates in the occupational environment able to develop a lung complication, for instance, pulmonary berylliosis and acute beryllium disease in respiratory systems.	[123]

[n] peak expiratory flow.
[o] maximum expiratory flow.

6. Conclusions

This review of previous studies on metal fumes toxicity and its connexion with lung health problems in automotive industry revealed the arising issues of pulmonary disease and disorder among welders. The welding metal-rich element of nickel, hexavalent chromium, iron, aluminium, cadmium and beryllium shows strong evidence in the progression of lung disease among welders. This review paper provides insights on the impacts caused by metals toxicity contained in welding fumed that was generated in the body shop area as this is an important issue for future research. Future studies, by utilizing the data gathered from this study may focus on developing pulmonary risk prediction model as a decision making tools in investigating the significant health impacts among metal-industries workers specifically to automotive welders.

Declaration and Acknowledgment
The authors firmly declare that there are no conflicts of interest related to this work and no funding was received.

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