International Journal of Scientific Research Updates

Journal homepage: https://orionjournals.com/ijsru/

ISSN: 2783-0160 (Online)

(RESEARCH ARTICLE)

Check for updates

Oxidative stress, antioxidant status and lung function test among iron welders in Sokoto, Nigeria

Abdullahi Sulaiman Mainasara [1], Usman Wali [2], Abdulmalik Ahmad Binji [2,*] and Adamu Jibril Bamaiyi [3]

[1] *Department of Chemical Pathology and Immunology, Usmanu Danfodiyo University, Sokoto,*
[2] *Department of Chemical Pathology, School of Medical Laboratory Sciences, Usmanu Danfodiyo University, Sokoto,*
[3] *Department of Physiology, Usmanu Danfodiyo University, Sokoto.*

International Journal of Scientific Research Updates, 2022, 03(02), 043–049

Publication history: Received on 26 March 2022; revised on 10 May 2022; accepted on 12 May 2022

Article DOI: https://doi.org/10.53430/ijsru.2022.3.2.0039

Abstract

Welding poses potential and chemical hazards because its fumes consist of a wide range of complex metal oxide particles which can be deposited in all regions of the respiratory tract. We aimed in the present study to determine lipid peroxidation and antioxidant status of Iron welders in Sokoto. The study involves 54 active welders and 20 age matched control males. Their lung function test (LFT) was carried out using spirometry and their blood was collected by venipuncture and analyzed for oxidative stress, antioxidant enzymes, vitamins and minerals via spectrophotometric methods. Serum levels of malondialdehyde (MDA), Cu-Zn superoxide dismutase (Cu-ZnSOD), glutathione peroxidase (GPx) and catalase (CAT) were significantly higher in welders ($p < 0.05$) when compared to non-welders. Peak Expiratory Flow Rate (PEFR) is significantly higher in welders ($P < 0.05$) than in non-welders. Across duration of occupational age exposure, levels of MDA,Vitamin A and GPx were significantly higher ($p<0.05$) when compared to other parameters. Pearson correlation indicated strong negative correlation between markers of oxidative stress and lung function test. The important findings among the sample of welders in comparison to controls are higher lung function test, antioxidant enzymes and vitamins.

Keywords: Oxidative Stress; Antioxidant; Lung Function Test; Metal Oxides

1 Introduction

Evidence from epidemiologic studies and case reports of workers exposed to welding emissions clearly establish the risk of acute and chronic respiratory disease [1]. The major concern however is the excessive incidence of lung cancer among welders [2]. A large body of evidence from regional occupational mortality data, case control studies, and cohort studies indicates that welders generally have about fourty percent (40%) increase of developing lung cancer as a result of their work experiences [1]. Increase in morbidity and mortality among welders appear to exist even when exposure have been reported to be below (36.4%) current occupational safety and health administration (OSHA) permissible exposure limits (PELs) for many individual components of welding emissions [3].

Similarly, prevalence of lung cancer among welders has been estimated to be around 40% [3]. Weldering particularly in an open place as it is being practiced in many areas may generate fumes that could travel long distance from the source (point of production) to increase potential health risk to oxidative stress [4].

Most of the welders are not aware of biohazards associated with their occupation. Thus, local data can be used in addressing the menace associated with this occupational hazard within our communities. This study will therefore

* Corresponding author: Abdulmalik Ahmad Binji
Department of Chemical Pathology, School of Medical Laboratory Sciences, Usmanu Danfodiyo University, Sokoto.

provide useful information on pattern of oxidative stress distribution in our environment using welders and apparently healthy non-welder participants. It will also offer guide in fume exposure intervention measures for welders or additional insight into the health risk associated with that occupation [4].

2 Material and methods

All chemicals and reagents used were of analytical grade and used before their expiration date. They were all bought from abcam, Discovery Drive, Cambridge Biomedical Campus, Cambridge, United Kingdom. Based on sample size calculation, only 54 welders were recruited in this study with 20 non welders serving as controls. About four (4) mL of venous blood was collected using standard venipuncture technique. The samples were transferred into plain bottle/tube. The tubes containing the samples were centrifuged for 10 minutes at 3000 revolution per minute (rpm) and serum was collected into clean, plastic vials and stored at – 200C until used.

After obtaining ethical approval for the research (Ref No. SMH/1580/V.IV) and getting informed consent from the participants as required by the Helsinki declaration guides, two groups of participants, one for welders (n =54) and the other for non-welders (n =20) were formed. Each of the group was subjected to comparative analysis or descriptive study approach. In this study, risk factor/exposure va riable was measured in both groups and differences in outcome were compared between the groups. The following methods were adopted in the measurement of biochemical parameters:

- Malondialdehyde (MDA) was estimated using Thiobarbituric Acid Reactive Substance (TBARS) by Wong et al (1987) [5].
- Ascorbic acid was measured using Dinitrophenylhydrazine (DNPH) described by Patriarca et al (1991) [6].
- Vitamin A was measured using Ferrozine reagent described by Ladoon et al (2013) [7].
- Vitamin E was measured using Tripyridyltrazine (TPTZ) reagent described by Martinek (1964) [8].
- Superoxide dismutase (SOD) was assayed using Nitroblue Tetrazolium (NBT) reaction described by Yamanaka et al (1979) [9]
- Glutathione Peroxidase (GPx) activity was measured using Cayman's reagent according to Paglia and Valentine (1967) [10].
- Catalase activity was measured using spectrophotometric method of Goth (1991) [11].
- Serum Zinc and Copper were measured by Atomic Absorption Spectrophotometer based on Al-Assaf (2010) [12].
- Serum Manganese was measured by AAS based on Folgering et al (1998) [13].
- Lung function test were determined using Peak Flow Metre (PFM) according to Folgering et al (1998) [13] and Fractional Exhaled Nitric Oxide (FENO) test according to American Lung Association (ALA) (2020) [14].

The results of the data were expressed as Mean ± Standard Deviation (SD) and comparison of the mean of groups was done using student *t*-test on statistical package for the social sciences (SPSS – IBM version 21) software. Pearson's correlation was used to show relationship or association between variables. Probability (i.e., P – value <0.05) was taken as statistically significant for all analysis.

3 Results

Table 1 Lung Function Test of Iron Welders based on PFER and FENO

PARAMETER	IW (N = 54)	NON-IW (N = 20)	P-VALUE
PEFR (L/MIN)	222.31±75.23*	131.25±15.43	0.003
FENO (PPB)	35.07±16.60	33.10±12.83	0.160

NB: Values are expressed as mean ± Standard Deviation (SD). PFER: Peak Flow Expiratory Rate; FENO: Fractional Exhaled Nitric Oxide; PPB: parts per billion; N: Numbers of subjects; IW: Iron welders, * p <0.0.5, ** = P <0.005, *** = P <0.0001

Table 2 Serum MDA and Antioxidant enzymes activities in Iron Welders

PARAMETER	IW (N = 54)	NON-IW (N = 20)	P-VALUE
MDA (NMOL/ML)	11.90±2.89**	5.54±2.59	0.0001
SOD1 (U/ML)	1.02±0.51**	0.98±0.62	0.003
SOD2 (U/ML)	0.91±0.49	1.27±0.42	0.080
GPx (μMOL/MIN/ML)	2.03±0.29**	1.10±0.03	0.001
CAT (KU/L)	0.81±0.86**	0.24±0.12	0.0001

NB: Values are expressed as mean ± Standard Deviation (SD). MDA: Malondialdehyde; SOD 1 and 2: Superoxide Dismutase 1 and 2; GPx: Glutathione Peroxidase; CAT: Catalase; N: numbers of subjects; NMOL/ML: nanomole per millilitre; U/ML: Unit per millilitre; NMOL/MIN/ML: nanomole per minute per millilitre; KU/L: katal Unit per Litre; IW: Iron Welders; Cu-Zn SOD 1; Mn-SOD 2, * p <0.0.5, ** = P <0.005, *** = P <0.0001

Table 3 Antioxidant Vitamins Level in Iron Welders

PARAMETER	IW (N = 54)	NON-IW (N = 20)	P-VALUE
VITAMIN A (μG/L)	18.08±4.13*	17.87±6.66	0.0010
VITAMIN C (MMOL/L)	0.98±0.17**	0.46±0.22	0.0001
VITAMIN E (MMOL/L)	0.90±0.53*	0.57±0.30	0.0300

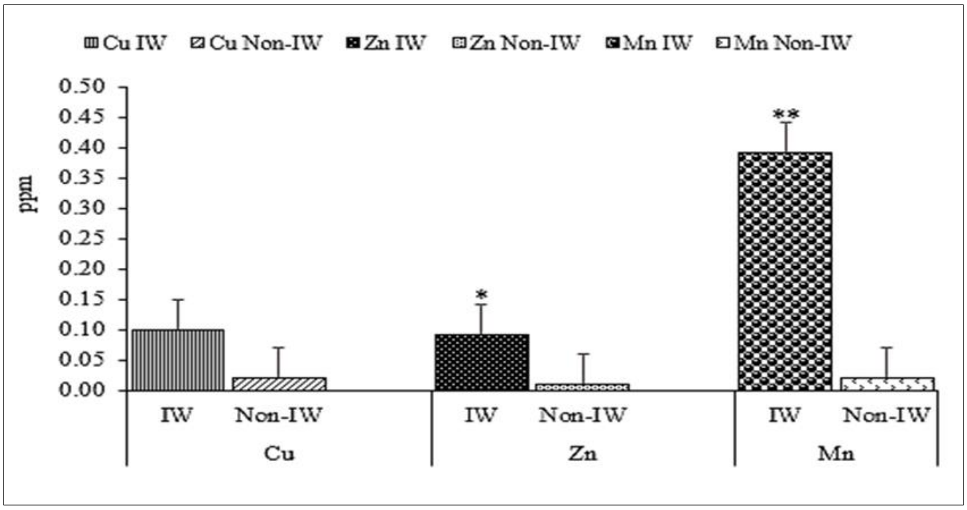
NB: Values are expressed as mean ± Standard Deviation (SD). n: numbers of subjects; mmol/L: millimole per ilitre; μg/dL: microgram per deciliter; IW: Iron Welders, * p <0.0.5, ** = P <0.005, *** = P <0.0001

Table 4 Effect of occupational age exposure on MDA and antioxidant status among the iron welders

PARAMETER	< 1- 8 years (N=22)	9 – 16 years (N =14)	17 – 24 years (N =10)	25 – 32 years (N =8)
MDA (NMOL/ML)	11.93±2.92	12.23±2.85	11.90±2.89	12.46±2.87
SOD-1 (U/L)	0.91±0.50	0.95±0.48	0.91±0.49	1.01±0.46
SOD-2 (U/L)	1.01±0.51	1.12±0.47	1.02±0.51	1.13±0.46
GPX (NMOL/MIN/ML)	2.03±0.30	2.08±0.08	2.03±0.29	2.09±0.08
CAT (KU/L)	0.81±0.66	0.83±0.65	0.84±0.76	0.86±0.70
V. A (μG/L)	18.01±4.11	18.00±4.27	18.08±4.13	17.72±4.26
V. C (MMOL/L)	0.98±0.18	1.01±0.17	0.98±0.17	1.02±0.18
V. E (MMOL/L)	0.91±0.55	0.86±0.53	0.90±0.53	0.87±0.52
CU (PPM)	0.04±0.02	0.07±0.05	0.08±0.06	0.06±0.04
ZN (PPM)	0.90±0.05	0.08±0.05	0.09±0.05	0.07±0.04
MN (PPM)	0.43±0.33	0.41±0.32	0.44±0.36	0.39±0.26

NB: Values are expressed as mean ± Standard Deviation (SD). MDA: Malondialdehyde; V.A: Vitamin A; V.C: Vitamin C; V.E: Vitamin E; MDA: Malondialdehyde; SOD 1 and 2: Superoxide Dismutase 1 and 2; CAT: Catalase; GPx: Glutathione Peroxidase; Cu: Copper; Zn: Zinc; Mn: Manganese; F: frequency; PPM: parts per million; NMOL/ML: nanomole per millilitre; U/ML: Unit per millilitre; NMOL/MIN/ML: nanomole per minute per millilitre; KU/L: katal Unit per Litre.

It has been shown in table 4 above that there were increases in the levels of the parameters measured as the length of exposure increases. It was more pronounced at 25 – 32 years.



NB: Values are expressed as mean ± Standard Deviation (SD). N: numbers of subjects; PPM: parts per million; IW: Iron welders. * p <0.0.5, ** = P <0.005, *** = P <0.0001

Figure 1 Serum Antioxidant Minerals in Iron Welders

4 Discussion

In the present study we reported the following important findings: Welders have significantly high peak expiratory flow rate (PEFR), malondialdehyde (MDA), superoxide Dismutase-1 (SOD-1), glutathione peroxidase (GPx) and catalase (CAT) compared to non-welders. And based on duration of occupational age exposure, we observed that MDA, SOD-1, and GPx were increased based on occupational age duration. Similarly, Pearson correlation of lung functions with all variables indicated that MDA has strong negative association, whereas all the antioxidant enzymes with exception of ZnSOD have lesser negative association with lung functions.

The higher PEFR is in line with the work of [15]. This could probably be due to the fact that iron welders may have been engaged in some sort of regular body exercise activities [16]. It was known that inhaled welding fumes poses greater risk for lipid peroxidation and lung diseases like asthma and chronic obstructive pulmonary disease (COPD) especially in sedentary individuals. In the same vein, it was suggested that welding fumes can be retained in tissues of athletes for long period of time without significant damage. However, freshly inhaled fumes induce greater lung inflammation than aged ones. Although this condition could be reversible, higher concentration of the reactive oxygen species (ROS) generated has been shown to cause irreversible tissue damage [17].

Higher serum levels of MDA are in consistent with those of [18]. Continuous inhalation of fume components that can instigate lipid peroxidation in response to transient acute inflammation have been shown to elevates MDA level. Since ROS have very short life span, tissue damage could be best observed via measuring the final product of lipid peroxidation such as the MDA [15]. The exact mechanism on how welding fumes cause oxidative stress is not clear. However, soluble substances in the fumes have been shown to mediate pro-inflammatory responses evidenced by increased level of interleukin-8 (IL-8) in both acute and chronic exposure [15].

Cu-ZnSOD level agrees with that of [3]. It was observed that most tumour cells as a result of chronic exposure to welding lacked SOD-2. This is in agreement with the work of [19] where its low molecular weight of Cu-ZnSOD (32kDA) make it readily available in extracellular fluid (ECF) compared to that of MnSOD (87kDA). Also because of its substantial concentrations in the cytoplasm and nucleus of cells, Cu-ZnSOD has elevated concentrations particularly during acute exposure or damage than MnSOD [3].

Increased serum GPx in welders was supported by [20] and may suggest adverse health conditions such as dysregulation of cell proliferation and apoptosis. However, because many welding activities are being conducted in an open place, possibility of extreme primary inhalation may be lessen in as much as large proportion of the gases does escape freely in atmosphere Leidel et al [21]. Elevated level of CAT in serum of welders may suggest an important role of the enzyme in maintaining homeostasis of the cells by degrading hydrogen peroxide, which is toxic at high concentrations in the body. This observation agrees with that of [22].

Serum levels of MDA, Vitamin A and GPx as was found higher compared to other parameters throughout the duration of occupational age agrees with work of [15]. However, the concept of dose- response relationship may help to offer an insight toward the observed trend. It vividly appears that the welders may have been exposed to variable amounts of fumes, for such an irregular duration of time. Also, uncertainties about smoking habits, possible interactions among the various components of welding emissions and possible extent of exposure to other occupational carcinogens may all contributed to the observed trend in this study, based on the occupational age exposure [23].

Strong negative correlation between lung function test and MDA observed is consistent with the work of [18]. This could explain the fact that oxidative stress may cause serious obstruction in the airway of welders leading to decrease lung functions as measured by PEFR [24]. Similarly, less correlation observed between lung functions and antioxidant enzymes might suggest micronutrient deficiency or toxicity. One of the initial responses to this condition is an early oxidative burst, characterized by high production of reactive oxygen species (ROS), causing severe cell damage such as lipid peroxidation and interfering with normal cell metabolism [25].

Other significant findings in this study were as follows: Levels of Cu, Zn and Mn showed significance increase in welders than in non-welders. The observations aligned to those of [24, 25]. Since most of the primary particles in different aerosols have diameter between 0.005 and 0.04μm, they can easily deposit throughout the respiratory system. Generally, the smaller the particles size, the complicated become their behavior. Studies have shown that almost all Cu, Mn, and Zn were in fraction of less than 300nm. This is an aerodynamic property of those particles, which in addition to their thermodynamic ones like impaction, sedimentation, and diffusion they have greater capabilities for tissue deposition/metal toxicity [15].

Observed significant increase in levels of vitamin A, C and E in welders may help confirm the possibility of oxidative stress [26]. Although these vitamins can function in redox reactions, other health conditions like atherosclerosis which could as well have a link with chronic exposure to welding fumes may show increased level of the vitamins [27].

The insignificant difference in FENO values may suggests no relationship between the study groups. Relevance of this observation was supported by [28]. However, variation and precision of FENO test increases with repeated measurement as well as with the use of different analyzers [29]. However, the present study may be considered to be limited for using only one type of the device.

5 Conclusion

In conclusion, PEFR, MDA, copper, and manganese levels as well as glutathione peroxidase enzyme activities were higher in iron welders compared to non-iron welders. Furthermore, blood pressure and antioxidant vitamins were higher compared to controls. The study further reveals that, the malondialdehyde level, superoxide dismutase-1, catalase and GPx enzymes activities were higher as occupational age duration increases. Vitamin A was found to be higher at early occupational age.

Recommendations

There is need for advocacy for safety in of occupational practices especially among the artisans such as encouraging the use of exhaust ventilation system or any ventilation system in welding practice. Especially, health education to the welders to wear respiratory protection such as air purifying respirator (APRs) and supplies air respirators (SARs) or airlines for reduction of exposure to welding fume.

A more robust study is hereby recommended to assess the genetic composition of welders which may further explain the contribution of such important factor in producing the results thus presented in the presented data. We also suggest that similar type of study but with larger sample size and prospective type be carried out, so that a causal effect conclusion can be drawn on welders on the parameters presented so far.

Compliance with ethical standards

Acknowledgments

We are indebted to the welders in Sokoto metropolis who offered to participate in the study as their own contribution towards understanding the health hazard associated with their occupation. We are also grateful to our colleagues at the Chemical pathology Department, School of Medical Laboratory Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria for the assistance during the chemical analysis of the participants samples.

Disclosure of conflict of interest

The authors declared no conflict of interest

Statement of informed consent

After obtaining ethical approval for the research (Ref No. SMH/1580/V.IV), informed consent were obtained from each participant and the rules guiding research on human subjects as required by the Helsinki declaration were adhered to.

References

[1] Olszanecki R, Gebska A, Kozlovski VI, Gryglewski RJ. Flavonoids and nitric oxide synthase. J Physiol Pharmacol. Dec 2002; 53(4 Pt 1): 571-584.

[2] Oberley LW, Buettner GR. Role of superoxide dismutase in cancer: a review. Cancer Res. Apr 1979; 39(4): 1141-1149.

[3] Controlling Hazardous Fumes and Gases During Welding. Occupational Safety and Health Administration (OSHA) FactSheet . 2013. www.osha.gov

[4] Sahabi SM, Abdullahi K. Epidemiological Survey of Malignant Neoplasms in Sokoto, Nigeria. *W*orld Journal of Research and Review. 2017. 4(4): 10 – 15.

[5] Wong SH, Knight JA, Hopfer SM, Zaharia O, Leach CN Jr, Sunderman FW Jr. Lipoperoxides in plasma as measured by liquid-chromatographic separation of malondialdehyde-thiobarbituric acid adduct. Clinical chemistry. 1987. 33(2 Pt 1): 214–220.

[6] Patriarca M, Menditto A, Morisi G. Determination of Ascorbic Acid in Blood Plasma or Serum and in Seminal Plasma Using a Simplified Sample Preparation and High-Performance Liquid Chromatography Coupled with Uv Detection. Journal of Liquid Chromatography. 1991; 14(2): 297-312.

[7] Jadoon S, Malik AY, Qazi MH, Aziz M. Spectrophotometric method for the determination of Vitamin A and E using Ferrozine-Fe(II) complex. Asian Journal of Research in Chemistry. 2013; 6: 334-340.

[8] Martinek RG. Method for the Determination of Vitamin E (Total Tocopherols) in Serum. Clinical Chemistry. 1964; 10(12): 1078-1086.

[9] Yamanaka N, Nishida K, Ota K. Increase of superoxide dismutase activity in various human leukemia cells. Physiol Chem Phys. 1979; 11(3): 253-256.

[10] Paglia DE, Valentine WN. Studies on the quantitative and qualitative characterization of erythrocyte glutathione peroxidase. J Lab Clin Med. Jul 1967; 70(1): 158-169.

[11] Góth L. A simple method for determination of serum catalase activity and revision of reference range. Clin Chim Acta. Feb 15 1991; 196(2-3): 143-151.

[12] Al-Assaf NA. Determination of Serum Trace Elements Magnesium, Copper, Zinc, and Selenium in Asthmatic Patients by Atomic Absorption Spectrophotometry. Journal of Al-Nahrain University. 2010; 13(1): 20-25.

[13] [13] Folgering H, vd Brink W, v Heeswijk O, v Herwaarden C. Eleven peak flow meters: a clinical evaluation. Eur Respir J. Jan 1998; 11(1): 188-193.

[14] American Lung Association (ALA). Exhaled Nitric Oxide Test. Lung Procedures, Tests and Treatments. 2020. https://www.lung.org.

[15] Riccelli MG, Goldoni M, Poli D, Mozzoni P, Cavallo D, Corradi M. Welding Fumes, a Risk Factor for Lung Diseases. International journal of environmental research and public health. 2020; 17(7): 2552.

[16] Antonini JM, CRW, Krishna M, Sreekanthan GG, Jenkins P, Eager N, Brain TW Freshly generated stainless steel welding fumes induces greater lung inflammation in humans as compared to age fumes. Toxicology letters. 1998; 98: 77 – 86.

[17] Gallagher RP, Threlfall WJ. Cancer mortality in metal workers. Can Med Assoc J. 1 Dec 1983; 129(11): 1191-1194.

[18] Cherian DA, Peter T, Narayanan A, Madhavan SS, Achammada S, Vynat GP. Malondialdehyde as a Marker of Oxidative Stress in Periodontitis Patients. Journal of pharmacy & bioallied sciences. 2019; 11(2): S297-S300.

[19] Kinnula VL, Crapo JD. Superoxide Dismutases in the Lung and Human Lung Diseases. American Journal of Respiratory and Critical Care Medicine. 2003; 167(12): 1600-1619.

[20] Tan BL, Norhaizan ME, Liew W-P-P, Sulaiman Rahman H. Antioxidant and Oxidative Stress: A Mutual Interplay in Age-Related Diseases. Frontiers in pharmacology. 2018; 9: 1162-1162.

[21] Leidel NA, Busch KA, Lynch J. Occupational exposure sampling strategy manual. Cincinnati, United States Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health. National Government Publication.1977.

[22] Nandi A, Yan LJ, Jana CK, Das N. Role of Catalase in Oxidative Stress- and Age-Associated Degenerative Diseases. Oxid Med Cell Longev. 2019; 9613090.

[23] Zaharieva T, GYaAJ. Dynamics of Metabolic Responses to Oxidative Stress. Animal Science. 2013; 166: 1045 – 1105.

[24] Shazia Q, Mohammad ZH, Rahman T, Shekhar HU. Correlation of oxidative stress with serum trace element levels and antioxidant enzyme status in Beta thalassemia major patients: a review of the literature. Anemia. 2012; 2012: 270923.

[25] Blasco Leon MB, Navarro-León E, Ruiz J. Oxidative Stress in Relation with Micronutrient Deficiency or Toxicity; 2018: 181-194.

[26] Bergström T, Ersson C, Bergman J, Möller L. Vitamins at physiological levels cause oxidation to the DNA nucleoside deoxyguanosine and to DNA--alone or in synergism with metals. Mutagenesis. Jul 2012; 27(4): 511-517.

[27] Salonen RM, Nyyssönen K, Kaikkonen J, et al. Six-Year Effect of Combined Vitamin C and E Supplementation on Atherosclerotic Progression. Circulation. 2003; 107(7): 947-953.

[28] Korn S, Wilk M, Voigt S, Weber S, Keller T, Buhl R. Measurement of Fractional Exhaled Nitric Oxide: Comparison of Three Different Analysers. Respiration. 2020; 99(1): 1-8.

[29] Alving K, Janson C, Nordvall L. Performance of a new hand-held device for exhaled nitric oxide measurement in adults and children. Respiratory Research. 2006/04/20 2006; 7(1): 67