Gold mining and acute respiratory infection in children –a retrospective cohort study in fiji

BACKGOUND

- Acute respiratory tract infections (ARIs) are heterogeneous and complex group of diseases caused by a wide range of pathogens in which the possible anatomic site (s) extend from the pharynx to the alveoli *(Ujunwa & Ezeonu, 2014)*

- The overall reported incidence of ARIs is 6-8 episodes during the first 5 years of life. *(Ujunwa & Ezeonu, 2014)*

- Consume significant health sector resources and long-term empiric treatment of ARIs contributes to the world-wide antibiotics resistance*(Ujunwa & Ezeonu, 2014)*

- Acute respiratory tract infections (ARIs) constitute the major causes of mortality and morbidity among under-five children of the developing world *(Ujunwa & Ezeonu, 2014)*

- Every year, ARIs in young children cause an estimated 3.9 million deaths worldwide. *(Fakunle, Ana & Ayede, 2013)*

)

- 5.9 million children <5yrs died in 2015. Pneumonia was one of the leading cause of death *(WHO, 2015).*

- ARI is the second leading cause of death among children under age five worldwide, after diarrhoeal diseases *(Kumar & Paul, 2016)*

- In 2012, WHO estimated that approximately one in every nine death was associated with exposure to air pollution *(WHO, 2017).*
- This makes air pollution the biggest environmental risk factor for ill health and the greatest environmental health crisis the world is facing.

- Exposure is a function of both the pollutant concentration in an environment, and the person-time spent in the environment. (Mishra, 2003; Smith and Mehta, 2003)

GOLD MINING AND ARI

- Gold mining processes emits harmful pollutants to the environment

- Potential emission sources on mines are complex. There is a wide range of source types, most are diffuse and highly changeable in nature, hard to measure, and site specific in relation to moisture content and silt. *(Schwegler, 2006)*

- E.g., hydrogen cyanide, arsenic compounds, sulfur dioxide, silica, suspended particulate matter

- Respiratory infection from mining communities in Obuasi, Ghana, were the result of air pollution emanating from the emission of dust and other chemicals into the air *(Kalaiselvi, Chinnakeli et al, 2014; Yeboah, 2011; Agyemang-Duah, Yeboah, 2016)*
- ARI accounted for 52% of diseases in Ntotroso, a mining community in Ghana *(Adei, Addei & Kwadjosse, 2011).* Dust suspension particularly mentioned as the cause of cough and cold

POSSIBLE POLLUTION SOURCES -VGM

Three basic steps

- Grinding and size classification to reduce the ore down to a fine particle size;
- Leaching and adsorption to extract the precious metals from the rock;
- Recovery of gold to produce dore bullion bars"

Transportation

Power-plant

Tailing dams

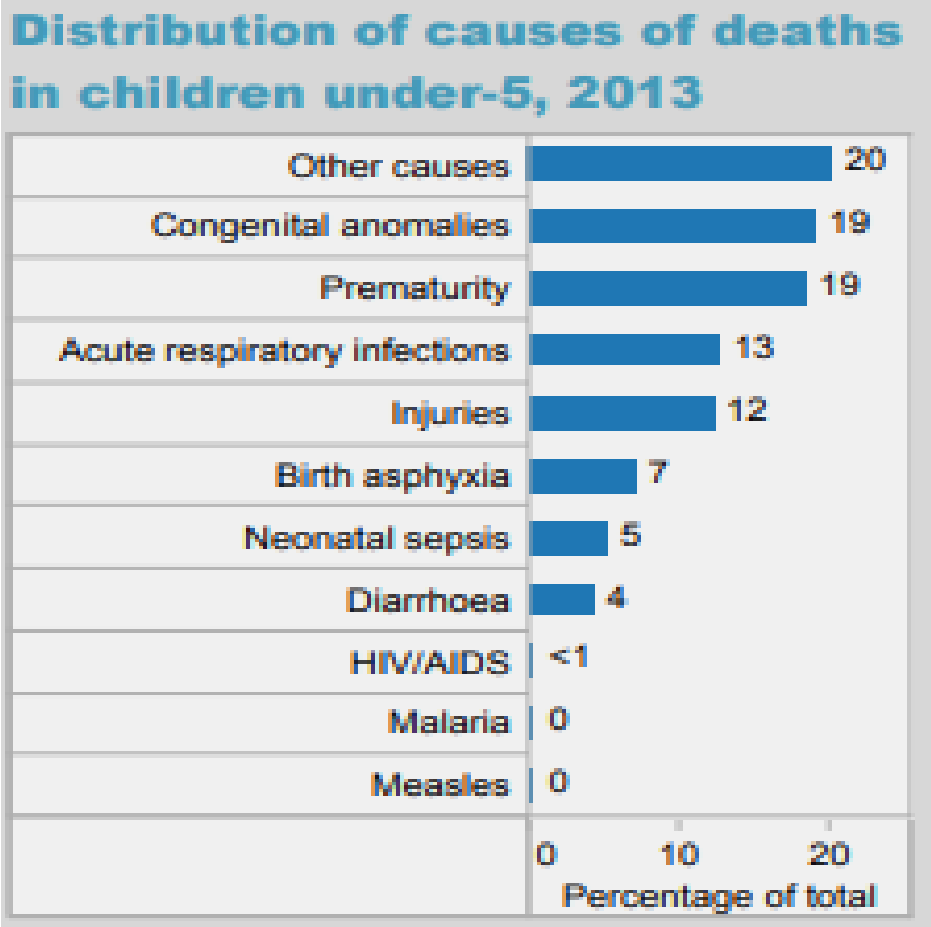
(high levels of silica noted in all dust samples collected from communities surrounding tailing storage facilities in Gauteng and the North-West, South Africa (Andraos, Utembe et al, 216).

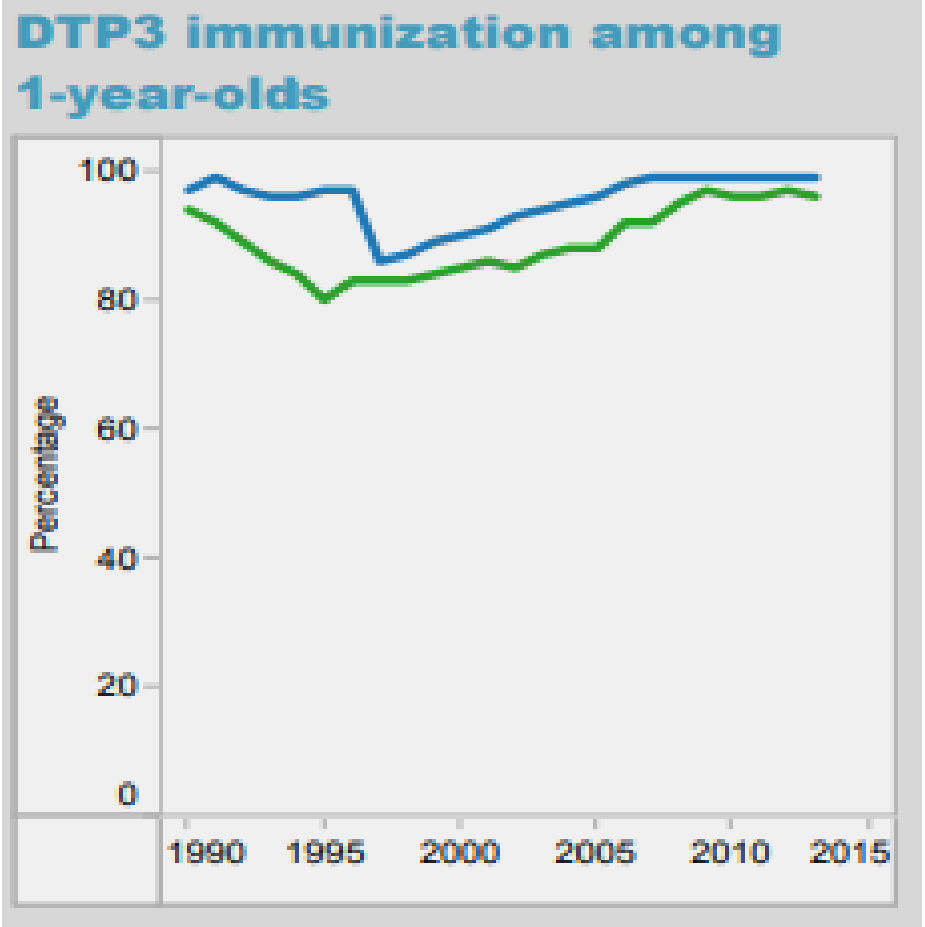
Underground exhaust

STUDY RATIONALE

- Mining industry growing in Fiji
- Minimal to insignificant health impact link
- Sulfur dioxide complain over the years
- First ever of such study in Fiji

CHILDREN UNDER





Source: WHO (2015) - http://www.who.int/gho/countries/fji.pdf?ua=1

- Fiji's neonatal and infant mortality rates are low compared to other developing countries *(Pacific Islands Forum Secretariat, 2012).*

- The under 5 mortality rate has decreased significantly over the last 5 years with general improvement noted in immunization status of one-year olds. *(MOH Fiji, 2015).*

- Pneumonia unspecified is the leading cause of admissions *(MOH Fiji, 2015).*

- In 2013 the Expanded Programme on Immunisation (EPI) in Fiji focuses on 12 infectious diseases

- Poor immunization status were found to significantly affect the prevalence of ARI, 50% of poorly immunized subjects had severe forms of ARI *(Ujunwa & Ezeonu, 2014)*

FIJI PROGRAMS TARGETING ARI IN CHILDREN <5YRS

- Vaccination (Pneumococcal and Hib)
- IMCI

  Treatment of pneumonia is based on classification.

  Early detection and treatment of cases

  Significant reduction in
- SDG alignment of activities (achievement of SDG goals+targets+indicators)

(SDG goal 3 target 3.2 is to end preventable deaths of new-borns and under-5 children by 2030) *(WHO, 2015)*

- Fiji on right track compared to other developing countries, but improvement needed in certain areas (NACD)

OBJECTIVES

- Compare ARI incidence, prevalence and survival rates of children between gold mining community and non-gold mining community
- Assess the effectiveness of programs targeting air quality and respiratory health in mining and in Fiji
- Recommend way forward to address loopholes in current practices.

STUDY SITE

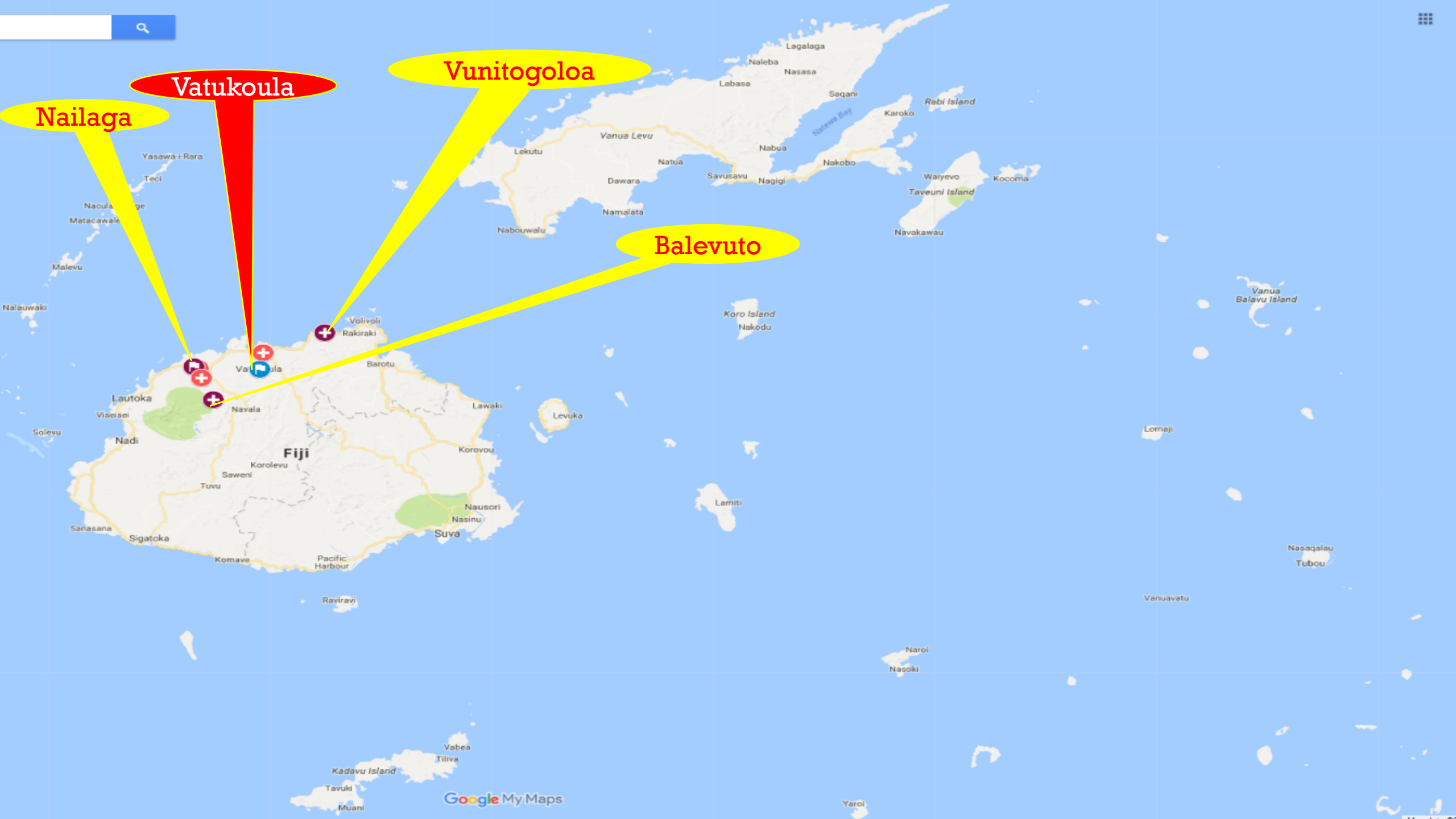
FIJI PROFILE

- Population (884,887: Urban-494,252; Rural-390,639)

  Race (2007: I-taukei-475,739: Indo-Fijians-313,798; Others-47,734)
- Life expectancy at birth m/f (2015): 67/73 *(WHO 2015)*
- Area – 18,376 sq km
- Source of revenue –tourism (Australia, New Zealand, USA as top markets)
- President of COP 23 (1st small island developing state to chair the UNFCCC COP process)
- The love of Rugby


Fiji
PHILIPPINES
FEDERATED STATES OF MICRONESIA
MARSHALL ISLANDS
Majuro
Ocean
PALAU
Koror
Palikir
CAROLINE ISLANDS
MALAYSIA
Tarawa
KIRIBATI
(GILBERT ISLANDS)
Yaren District
NAURU
KIRIBATI
(PHOENIX ISLANDS)
KIRIBATI
INDONESIA
PAPUA NEW GUINEA
SOLOMON ISLANDS
Honiara
TUVALU
Funafuti
Port Moresby
TIMOR-LESTE
Arafura Sea
Indian Ocean
Coral Sea Islands
(AUSTRALIA)
Coral Sea
VANUATU
Port-Vila
New Caledonia
(FRANCE)
FIJI
Suva
SAMOA
Apia
Pago Pago
American Samoa
(U.S.)
TONGA
Nuku'alofa
Niue
(N.Z.)
Cook Islands
(N.Z.)
Papeete
SOCIETY ISLANDS
ARCHIPEL DES TUAMOTU
Avarua
French Polynesia
(FRANCE)
ILES TUBUAI
Adamstown
Pitcairn Islands
(U.K.)
Noumea
AUSTRALIA
GREAT DIVIDING RANGE
Darwin
Cairns
Townsville
Mackay
Mount Isa
Alice Springs
Port Hedland
GREAT SANDY DESERT
GIBSON DESERT
GREAT VICTORIA DESERT
SIMPSON DESERT
Toowoomba
Brisbane
Gold Coast
Geraldton
Kalgoorlie
Broken Hill
Whyalla
Esperance
Adelaide
Canberra
Sydney
Wollongong
Melbourne
Geelong
Great Australian Bight
Tasman Sea
Kingston
Norfolk Island
(AUSTRALIA)
KERMADEC ISLANDS
(N.Z.)
North Island
Auckland
Hamilton
Tauranga
NEW ZEALAND
Palmerston North
Napier
Wellington
Christchurch
South Island
Dunedin
Tasmania
Hobart
Indian Ocean
South Pacific Ocean
Scale 1:41,000,000
Mercator Projection


Northern Division
Labasa
Vanua Levu
Savusavu
Tavenui
Western Division
Yasawas
Vanua Balavu
Koro
Mamanucas
Lautoka
Nadi
Viti Levu
Suva
Sigatoka
Ovalau
Gau
Central Division
Lakeba
Eastern Division
Vatulele
Moala
Kadavu
Fulaga
Source: MOH, Fiji


Nailaga
Vatukoula
Vunitogoloa
Balevuto
Lagalaga
Naleba
Nasasa
Labasa
Saqani
Rabi Island
Karoko
Natewa Bay
Vanua Levu
Lekutu
Nabua
Natua
Nakobo
Dawara
Savusavu
Nagigi
Waiyevo
Kocoma
Taveuni Island
Namalata
Nabouwalu
Navakawau
Yasawa-i-Rara
Teci
Malevu
Nalauwaki
Volivoli
Rakiraki
Barotu
Koro Island
Nakodu
Vanua Balavu Island
Lautoka
Navala
Viseisei
Lawaki
Levuka
Solevu
Nadi
Fiji
Korovou
Korolevu
Saweni
Tuvu
Lomaji
Lamiti
Nausori
Nasinu
Suva
Sanasana
Sigatoka
Komave
Pacific Harbour
Nasaqalau
Tubou
Vanuavatu
Raviravi
Naroi
Nasoki
Vabea
Tiliva
Kadavu Island
Tavuki
Muani
Yaroi
Google My Maps

METHODOLOGY

- Study design

Retrospective cohort

Key informant interview and focus group discussion conducted to answer the second objective

- Study areas

Gold mining cohort –Vatukoula Medical Area

Non-gold mining cohort – Nailaga Nursing Zone, Vunitogoloa Nursing Zone Balevuto, Vunitogoloa

PARTICIPANT AND DATA SOURCE

- **Participants**

-***Children <5years*** (Vatukoula(132), Vunitogoloa(63), Nailaga(72), Balevuto (70)

-Special risk group. Respiratory system not completely developed until the age of 6 *(Fuentes-Leonarte, Ballester and Tanias, 2009)*

-Breath more air in proportion to their weight than adults *(Fuentes-Leonarte, Ballester and Tanias, 2009)*

-may be longer active than adults in environment with high level of pollutants and inhale higher doses of pollutants (Giovannini, Sala, et al,2010)

-All those born in 2011 from mothers registered in the area.

-Followed-up until they reach their 5th birthday in 2016

- **Data Source**

IMCI register

Patients folder

VARIABLES

- Exposure variable

Living in/out of vicinity of gold mining area

- Outcome Variable

ARI

(severe pneumonia (1), pneumonia(2), no pneumonia cough or cold(3))

- Potential confounders

Gender

Ethnicity

Birthweight

Climate

ANALYSIS

- Software - RStudio
- Two-way tables –test the association between the categorical variables
- Survival analysis

– to calculate the probability of ARI free between the two groups at time t

-plot Kaplan-Meier curve -

SURVIVAL ANALYSIS

- **Event**

Occurrence of first ARI

- **Time to event/censored**

Time to event = date of first ARI – date of birth

Time of censored = date of censored – date of birth

(censored –lost to follow-up / yet to have the ARI at the end of observation period)

RESULTS AND DISCUSSION

DESCRIPTIVE STATISTICS

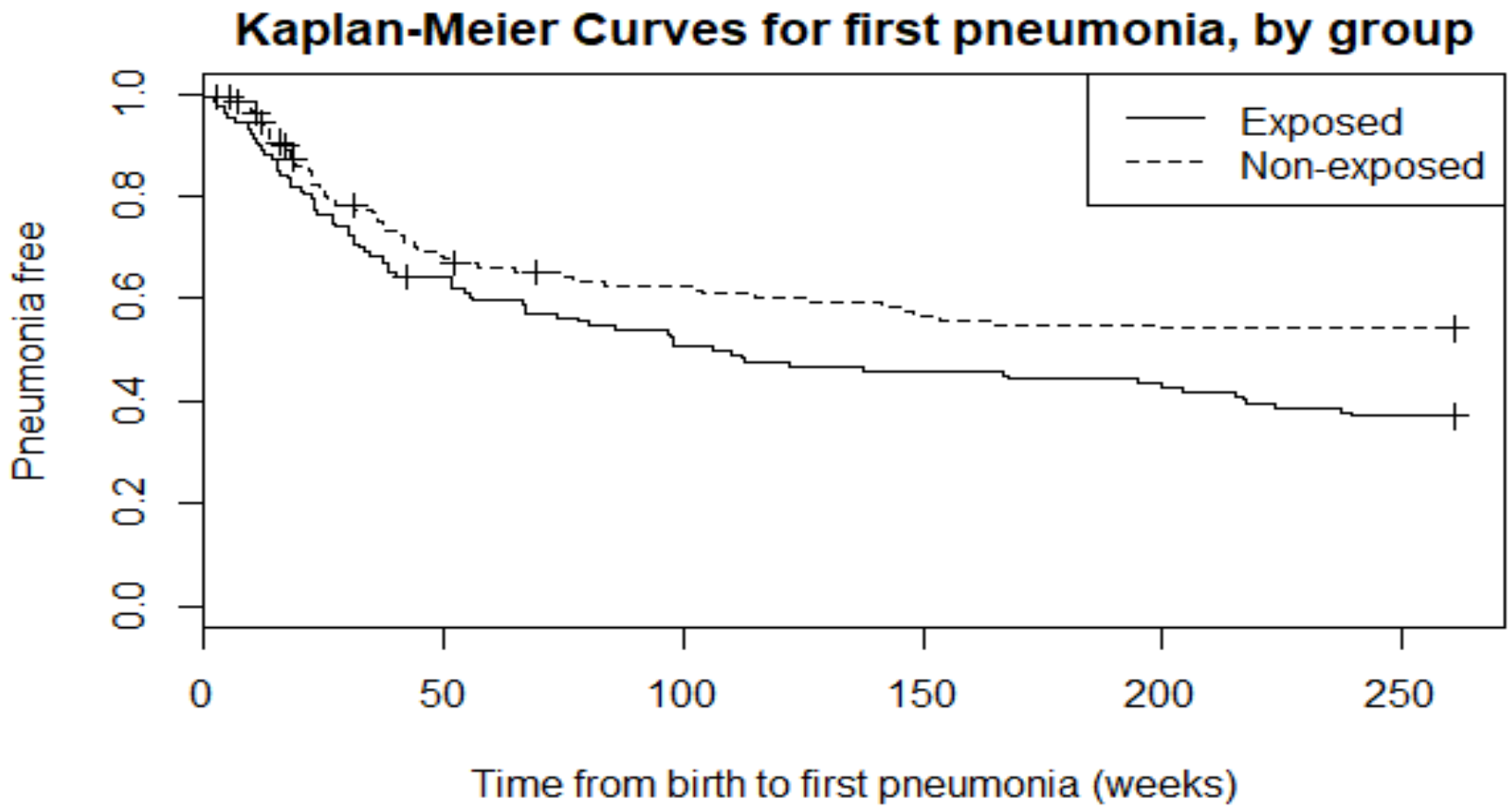
Characteristics	**Exposed**		**Non-exposed**		
	(No)	(%)	(No)	(%)	
Gender					
Male	55	36.91	94	63.09	p = 0.52
Female	77	40.96	111	59.04	
Ethnicity					
I_taukei	115	52.04	106	47.96	p < 0.01
Indo_Fijian	13	11.71	98	88.29	
Other	4	80	1	20	

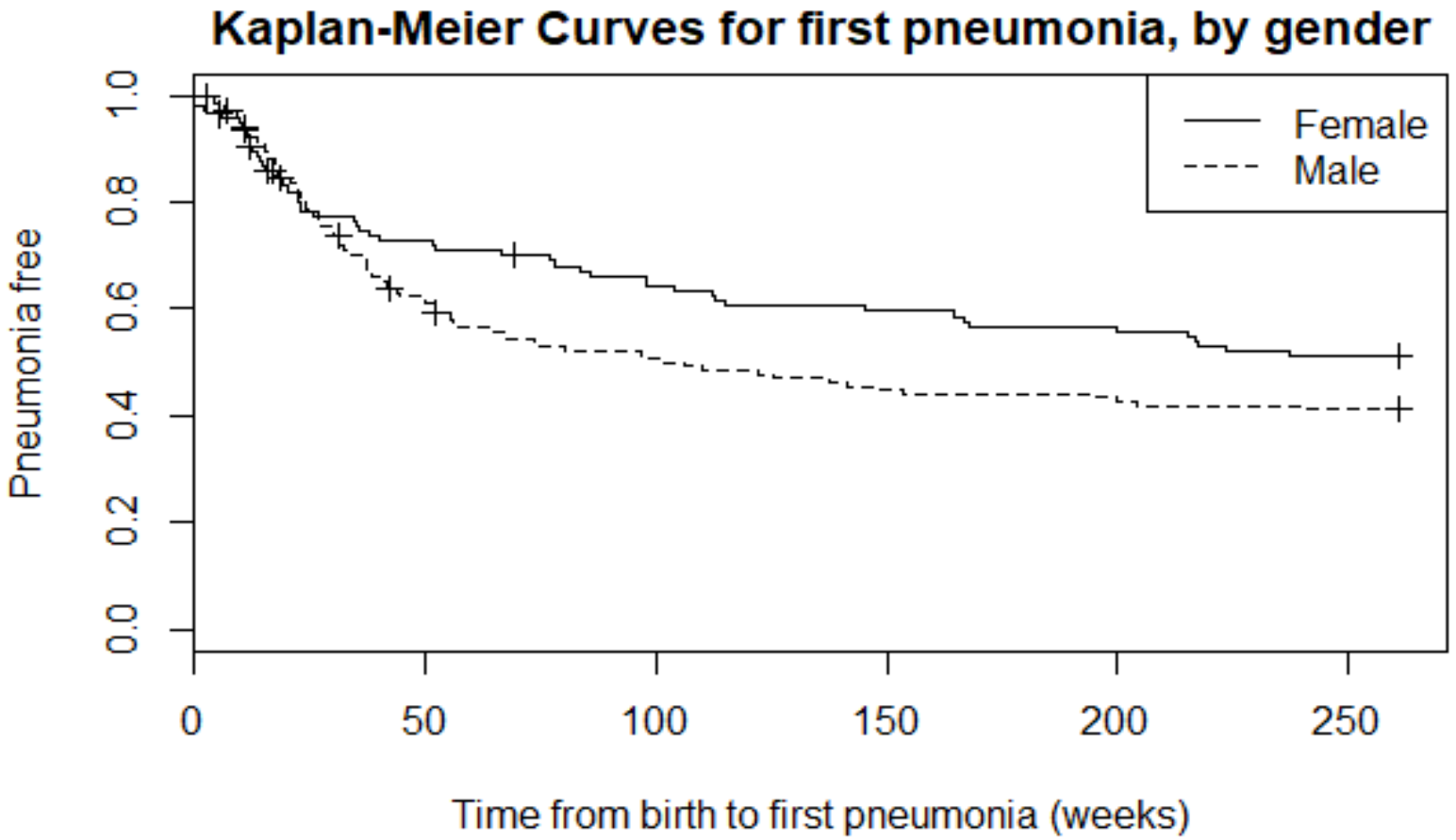
DESCRIPTIVE STATISTICS

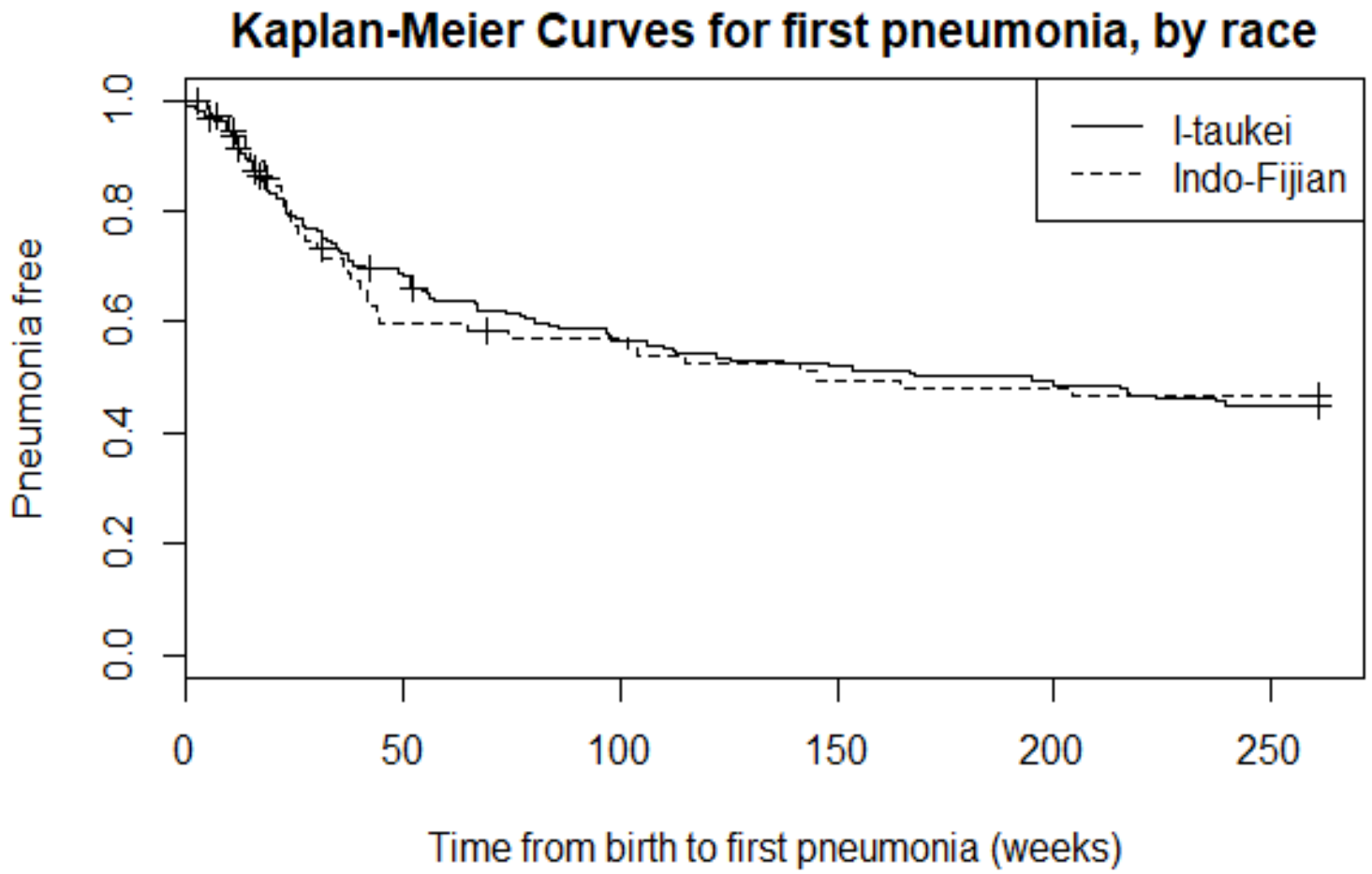
Characteristics	***Without ARI***		***With ARI***		
	(N)	***(%)***	***(N)***	***(%)***	
Address					
Exposed	49	37.12	83	62.88	p = 0.99
Non-exposed	77	37.56	128	62.44	
Gender					
Female	62	41.61	87	58.39	p = 0.189)
Male	64	34.04	124	65.96	
Ethnicity					
I-taukei	87	39.37	134	60.63	p = 0.559
Indo-Fijian	37	33.33	74	66.67	
Other	2	40	3	60	

Characteristics	Did not suffer ARI		No Pneumonia Cough or Cold		Pneumonia		Severe Pneumonia or Severe Disease		
	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	
Address									
Exposed	48	37.5	1	0.78	78	60.9	1	0.78	p < 0.01
Non-exposed	76	37.3	72	35.3	53	26	3	1.47	
Gender									
Female	61	41.2	34	23	53	35.8	0	0	p = 0.151
Male	63	34.2	39	21.2	78	42.4	4	2.17	
Ethnicity									
I-taukei	87	39.4	36	16.3	94	42.5	4	1.81	p < 0.01
Indo-Fijian	37	33.3	37	33.3	37	33.3	0	0	

KAPLAN-MEIER CURVES




Kaplan-Meier Curves for first pneumonia, by gender
Pneumonia free
0.0
0.2
0.4
0.6
0.8
1.0
0
50
100
150
200
250
Time from birth to first pneumonia (weeks)
Female
Male


Kaplan-Meier Curves for first pneumonia, by race
Pneumonia free
0.0
0.2
0.4
0.6
0.8
1.0
0
50
100
150
200
250
Time from birth to first pneumonia (weeks)
I-taukei
Indo-Fijian

SUMMARY OF KEY FINDINGS

- The occurrence of pneumonia is more in the exposed group
- Males had higher probability of having pneumonia
- I-taukei are more likely to have pneumonia

REMAINING ANALYSIS

- Log rank test (test difference in the two Kaplan-Meier curves)

- Hazard and hazard ratio (relative risk)

Quotient of hazard of the two groups and will state how much higher is the pneumonia rate in exposed group than in the non-exposed group

- Cumulative incidence

- Cox proportional hazard model (gender, ethnicity, birthweight, and climate)

The rates of ARI are likely to be confounded by the above factors. Cox regression will predict the likely effect of these factors.

DISCUSSION

- Pneumonia and Gender

Author	Title	Method	Result
Kumar & Paul, 2016	Effects of indoor air pollution on acute respiratory infection among children in India	National Family Health Survey (multivariate logistic regression)	Male children are more likely to suffer from ARI than female children.
Krishnan, Amarchand , et al, 2015.	*Epidemiology of acute respiratory infections in children - preliminary results of a cohort in a rural north Indian community*	*Prospective cohort study of children aged 0-10yrs*	*ALRI incidence in the under-five age group was higher among boys* *Boys had 2.4 times higher ARI-related hospitalization rate as compared to girls*

- Gender and pneumonia

Author	Title	Method	Result
Magree, Russell, et al, 2005	*Chest x-ray confirmed pneumonia I children in Fiji*	*Retrospective review of cases admitted at CWM on the first 10 days of each month from 2001-2002*	*The incidence appeared to be higher in Melanesian Fijian (I-taukei) than Indo-Fijian* ***First study to document the incidence CXR-confirmed pneumonia in a Pacific Island Country, and demonstrate a high incidence*
Russell, Carapetis et al, 2006	Pneumococcal nasopharyngeal carriage and patterns of penicillin resistance in young children in Fiji	Nasopharyngeal (NP) swabs	Higher rates of Streptococcus pneumoniae were found in the indigenous Fijian population..
Flynn, 1994	Respiratory symptoms of rural Fijian and Indian in Fiji	Cross-sectional survey	Fijian children have higher admission rates for pneumonia Fijians have higher prevalence of productive cough

- Ethnicity and Pneumonia

Author	Title	Method	Result
Magree, Russell, et al, 2005	*Chest x-ray confirmed pneumonia I children in Fiji*	*Retrospective review of cases admitted at CWM on the first 10 days of each month from 2001-2002*	*The incidence appeared to be higher in Melanesian Fijian (I-taukei) than Indo-Fijian **First study to document the incidence CXR-confirmed pneumonia in a Pacific Island Country, and demonstrate a high incidence*
Russell, Carapetis et al, 2006	Pneumococcal nasopharyngeal carriage and patterns of penicillin resistance in young children in Fiji	Nasopharyngeal (NP) swabs	Higher rates of Streptococcus pneumoniae were found in the indigenous Fijian population..
Flynn, 1994	Respiratory symptoms of rural Fijian and Indian in Fiji	Cross-sectional survey	Fijian children have higher admission rates for pneumonia Fijians have higher prevalence of productive cough

- Air quality and pneumonia

Author	Title	Method	Result
Dherani, Pope, et.al (2008)	Indoor air pollution from unprocessed solid fuel use and pneumonia in children aged under 5 years: a systematic review and meta-analysis.	Systematic review and meta-analysis	Risk of pneumonia in young children is increased by exposure to unprocessed solid fuels by a factor of 1.8
Isabelle, Jonathan, et al (2002)	Outdoor air pollution and acute respiratory infections among children in developing countries	Review	Short-term follow-up and time series studies suggest that air pollutants acts as risk factors for respiratory infection Air pollution exposure increases the incidence of upper- and lower-respiratory infections in children.
Gouveia N, Fletcher T (2000)	*Respiratory diseases in children and outdoor air pollution in Sao Paulo, Brazil: a time series analysis*	*Time series analysis*	*Daily admissions of children to hospital for total respiratory disease and pneumonia showed significant increases associated with O3 (5–8%), NO2 (9%), and with PM10.* *Consistently, effects for pneumonia were greater than for all respiratory diseases combined.*
Liu, Wang, et al, 2012	Effects of Outdoor and Indoor Air Pollution on Respiratory Health of Chinese Children from 50 Kindergartens	Cross-sectional study of children aged 3-7years	The prevalence of respiratory symptoms was higher among children living near a busy road, those living near chimneys or a factory, those having a coal-burning device, those living with smokers, and those living in a home that had been recently renovated.

CHALLENGES

MOH

- Low health seeking behaviour
- Reporting system (MoHMS)

Air QUALITY MONITORING AND MANAGEMENT

#IMRPOVEMENT

- Enforcement of regulations
- Abiding to regulations
- Resource constraints –manpower, finance, equipment (SEO-West)
- No reliable air quality data to predict the impacts

VGM

- 80 yr old mine –old infrastructure
- Planning issues –residential communities around mine
- No reliable air quality data to predict the impacts

CONCLUSION

Objective 1

- Pneumonia prevalence is high in the exposed group
- The non-exposed group had a high probability of being free from pneumonia at the end of 5 years.

Objective 2

- A lot of improvement is needed in addressing air quality in Fiji.