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Pregnancy Outcomes Associated with Chronic Indoor Air Pollution-Related Maternal Respiratory III Health in Ndola and Masaiti, Zambia

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Abstract

Introduction: Adverse pregnancy outcomes have been associated with impaired lung function and increased respiratory symptoms among women using biomass for cooking/heating houses. We investigated the association between maternal respiratory health and pregnancy outcomes among pregnant women predominantly using biomass for cooking/heating in Masaiti and Ndola, Zambia.

Methods: A cross-sectional study involved collection of information from 1,170 consenting pregnant women using a standard questionnaire and Spirometry conducted simultaneously. Data was analyzed using Stata Version 13 and association between maternal respiratory health and birth outcomes determined after adjusting for potential confounders using multivariate logistic regression analysis.

Results: The mean differences of lung function were statistically significant between mothers of LBW and those of normal weight; FEV_1/FVC (p value 0.023) and FVC (p value 0.0176). The mean differences were statistically significant between mothers of SGA babies and those of normal; FEV_1/FVC (p value < 0.0001) and FEV_1 (p value 0.0134). There was a statistically significant association between FEV_1/FVC and preterm in the urban (p value<0.0001) and small for gestational age (p value<0.0001) in the rural area for all the three trimesters. In the urban area, LBW was statistically associated with recurrent nasal symptoms OR [1.69 (95% C.I; 1.0-2.8)] and prolonged secretion of phlegm OR [0.58 (95% C.I; 0.3-1.0)]. In the multivariate analysis, there was a significant association between FVC and LBW in the rural area OR [0.09 (99% C.I; 0.0-0.4)]. Preterm delivery was statistically significantly associated with FVC OR [0.39 (99% C.I; 0.2-0.8)] in the entire study population.

Conclusion: Our results demonstrated substantial increased risk of several adverse pregnancy outcomes for pregnant women with poor respiratory health. These findings suggest the need for cleaner fuels for cooking and better ventilated cooking environment for the poor women who are the main victims in this health hazard. The respiratory health of pregnant women needs to be constantly monitored using Spirometry.

Keywords: Biomass; Spirometry; Respiratory symptoms; Low birth weight; Preterm; Small for gestational age

Introduction

Chronic exposure to emissions from solid fuels such as wood, charcoal, crop residues and cow dung is a significant cause of ill health conditions such as chronic obstructive lung diseases (chronic bronchitis and asthma), lung cancer, acute respiratory infections (ARI) in children and pregnancy-related outcomes [1]. In sub-Saharan Africa and many other low income countries where the main energy source for cooking/heating houses is biomass, women are chronically exposed to emissions which contain a lot of pollutants harmful to their health. Many other studies in developing countries have demonstrated a number of health effects linked to household biomass combustion and these include chronic obstructive pulmonary disease (COPD), asthma, respiratory infection, heart diseases, pulmonary diseases, cataract and adverse pregnancy outcomes [2,3]. In all these health burdens, women and children carry the heaviest burden compared to men; they are more susceptible to these health problems from household air pollutants because they spend longer times in the home environment [4,5]. A large body of evidence exists of biomass fuel being a significant contributor to increased respiratory symptoms and impaired lung functions [4,5].

Many studies have explored the relationship between pregnancy outcomes and exposure to air pollution due to indoor biomass combustion [6], second hand smoking [7] or smoking in pregnancy [8] but very few have tried to relate maternal respiratory symptoms and lung function to pregnancy outcomes. It is clear now that combustion products of unprocessed biomass fuels used by the poor urban and rural people for cooking and heating the house are the most important causes of indoor air pollution in developing countries. Indoor biomass fuel smoke has been shown to adversely affect the host defense against the respiratory infections and causes inflammation of airways and alveoli and it is thus plausible that it increases the incidence of respiratory ill health among the exposed [9, 10]. Since air pollution has been associated to a number of adverse pregnancy-related outcomes, and then maternal respiratory health, influenced by indoor air pollution should have an influence on pregnancy-related outcomes. However, there has been a paucity of epidemiologic evidence regarding the relationship between maternal respiratory health and pregnancy-related outcomes. Although there is a lack of evidence investigating how maternal respiratory health is associated with adverse pregnancy outcomes, it appears that respiratory health of the woman is linked to the pregnancy outcome through the impact of chronic indoor air pollution exposure, a situation that is common in many developing.

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Other available associations of maternal respiratory health and lung functions are those that demonstrate that adverse environment in utero may affect fetal growth and have lasting effects on lung function in adulthood and old age [11]. For instance, previous studies indicate that low birth weight predicts lower lung function later in adult life after adjusting for maternal and adult factors [12]. However, this is not the focus for our study; the focus for our study is to relate maternal respiratory health with selected birth outcomes such as low birth weight, preterm birth and small for gestational age and available research has shown that poor maternal respiratory health is associated with intrauterine factors that affect fetal growth [13]. Studies elsewhere have also shown that suboptimal lung function in pregnancy is associated with adverse birth outcome [14]. The study of the relationship between asthma during pregnancy and selected infant and maternal outcomes, after significant confounding variables are adjusted for, gives important information regarding the association between respiratory ill health during pregnancy and several adverse infant outcomes, including preterm birth, small for gestational age and maternal outcomes like idiopathic preterm labor [15]. In addition this, several other studies previously have evaluated the association between birth weight and lung function with some, [11,16] though not all obtaining positive association. Therefore, this study aims at investigating the relationship between maternal respiratory ill health and pregnancy-related outcomes.

Materials and Methods

Questionnaire

A structured questionnaire was used to obtain information on background characteristics and symptoms of respiratory conditions.

Spirometry

Lung function was determined using a spirometer, MIR Spirobank-G (Italy) with an attached printout of forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), and FEV_1/FVC% ratio.

For each assessment a research nurse demonstrated the technique to the participant. The participants then performed some practice efforts. They were then required to perform a minimum of three reproducible FVC measures (within 5% of maximum FVC produced). The output that produced the highest sum of FVC and FEV_1 were used in the analyses. Women who could not perform three reproducible measures or who were unable to attempt the lung function assessment were excluded. All assessments were carried out by one of nine research nurses who were trained to carry out the assessment in a similar manner.

Pregnancy outcomes

Pregnancy outcomes were recorded by the research nurse and the main outcomes of interest in the study were low birth weight (LBW), preterm birth (PTB) and small for gestational age (SGA). Neonatal length, weight and gestation age on delivery was recorded by the study nurse immediately after birth. General maternal health status, sex of the neonate and birth order was recorded together with any other birth outcomes such as stillbirth and congenital abnormalities.

Data processing and analysis

Lung function parameters of interest were categorized as follows: FEV_1/FVC%: > 70 is Normal, FEV_1% and FVC%: >80 is Normal. In the logistic regression, categories mild to severe were classified as impaired lung function. Preliminary analysis involving bivariate analysis was conducted in Epi Info. The independent predictors of outcome were obtained using the stepwise logistic regression in SPSS. Magnitudes of association were estimated using odds ratios and their 95% confidence intervals. Statistical significance was set at 5%. Ethical Consideration: The project was approved by the tropical Diseases Research Centre (TDRC) Ethics Committee. Further approval was obtained from the Zambia Health Research Authority of the Ministry of Zambia.

Results

Background characteristics

Out of a total of 1,210 pregnant women recruited from the nine antenatal clinics (ANC), forty (3.3%) households were excluded from the analysis due to incompleteness of data and failure to perform three

	Rural %	95% CI	Urban %	95% CI	Total %	95% CI	Population Estimates
Cough	20.6	[17.3-24.3]	31.1	[27.8-34.6]	28.5	[25.9-31.3]	6,850
Sputum	48	[43.8-52.3]	45.3	[41.7-49.0]	45.9	[43.0-48.9]	11,037
Wheezing	33.7	[29.8-37.8]	29.3	[26.1-32.8]	30.4	[27.7-33.2]	7,296
Breathlessness	17.3	[14.3-20.8]	16	[13.5-18.8]	16.3	[14.2-18.6]	3,910
Nasal Symptoms	40.7	[36.6-45.0]	47.2	[43.5-50.8]	45.6	[42.7-48.6]	10,956
Throat Symptoms	36.9	[32.8-41.1]	31.6	[28.3-35.1]	32.9	[30.2-35.7]	7,901

Table 1: Showing proportions of maternal respiratory symptoms according to region.

	Rural %	95% CI	Urban %	95% CI	Total %	95% CI	Population Estimates
FEV_1/FVC							
<70	0.4	[0.1-1.6]	0.7	[0.3-1.7]	0.7	[0.3-1.4]	156
70	0.2	[0.0-1.4]	0		0.1	[0.0-0.3]	12
>70	99.4	[98.2-99.8]	99.3	[98.3-99.7]	99.3	[98.6-99.7]	23,852
FEV_1							
Moderate Obstruction	0		1.5	[0.8-2.6]	1.1	[0.6-2.0]	264
Mild Obstruction	34.1	[30.2-38.3]	39.8	[36.2-43.4]	38.4	[35.5-41.3]	9,221
Normal	65.9	[61.7-69.8]	58.8	[55.1-62.3]	60.5	[57.6-63.4]	14,535
FVC							
Moderate Reduction	28.1	[24.4-32.1]	26.6	[23.4-29.9]	26.9	[24.4-29.6]	6,468
Mild Reduction	34.7	[30.8-38.9]	38.3	[34.8-41.9]	37.4	[34.6-40.4]	8,994
Normal	37.2	[33.2-41.4]	35.1	[31.7-38.7]	35.6	[32.8-38.5]	8,559

Table 2: Showing proportions of lung function of participants according to region.

reproducible Spirometry measures or who were unable to attempt the lung function assessment, leaving a total of 1,170 participants for analysis. Majority (80%) of the participants enrolled in the study were 35 years and below. Close to three thirds (91.2%) of the participants were married and over half (54.6%) had attained secondary and a third (30.0%) primary education.

Above two thirds of the participants (69.6%) were unemployed housewives. Over a quarter participants (87.8%) were taking nutritional supplements (ferrous sulphate and folic acid) and about the same proportion (84.6%) were under malaria chemo prophylaxis-Fansida. Close to one fifth (19.7%) of participants took alcohol and only 3.1% cigarette smoking in pregnancy. Hypertension was reported in 3.7% and diabetes in 1.8%.

Respiratory symptoms of the pregnant women in the study population

The summary of the maternal respiratory symptoms in the study population has been shown in Table 1. Majority (71.5%)of the pregnant women reported prolonged cough, while not having flu, during the last 12 months and close to half (45.9%) of them had recurrent secretion of phlegm from lungs during the last 12 months. Close to one third (30.4%) of the pregnant women reported wheezing during the last 12 months (wheezing caused by bronchi, not nose) while 16.3% of the pregnant women presented with uncomfortable feeling of breathlessness (tight chest and complicated breathing), during the last 12 months.

Prolonged nasal symptoms when not having flu during the last 12 months were reported by 45.6% of the pregnant women and about one third (32.9%) presented throat symptoms when not having a flu during the last 12 months.

Lung function test results of the pregnant women in the study population

Almost all the pregnant women (99.3%) had an FEV_1/FVC higher than 70% and close to two thirds (60.5%) of pregnant women had a normal FEV_1 while more than one third (38.4%) recorded mild obstruction. Normal FVC was obtained in 35.6% of pregnant women while mild reduction and moderate reduction was recorded in 37.4% and 26.9% of pregnant women respectively. Only a very small proportion (0.4%) of the population presented with COPD **(Table 2).**

Pregnancy outcomes in the study population according to region (Table 3)

Mean differences of selected birth outcomes between rural and urban (Table 4)

There was a statistically significant difference in gestational age and neonatal weight between rural and urban areas.

Mean differences of selected lung function parameters between rural and urban area

The mean FEV_1/FVC were 96.69% (SD 0.64) and 104.2% (SD 0.43) respectively observed in rural and urban area. The two means varied significantly with a p-value of <0.0001. The mean FVC between rural and urban did not vary significantly while the mean FEV_1 in the rural (84.75% SD 0.44) and urban (83.07% SD 0.39) varied significantly with the p-value 0.003. Table 5 below presents the mean differences of the lung functions together with the standard error, standard deviations, and p-values at 95% confidence interval between rural and urban area.

There were statistically significant mean differences in FEV_1/FVC (p value<0.0001) and FEV_1 (p value=0.003) between rural and urban areas.

Mean differences of lung functions between mothers of LBW and of normal weight babies

There was a significant variation with a p-value of 0.023 at 95% C.I of 100.37%-101.86% between the mean FEV_1/FVC (101.60%, SD 12.31) of mothers to normal weight babies and mothers to babies who had a low birth weight (99.92%, SD 14.55). The mean difference was 1.68% with a standard error of 0.84. The mean FVC for mothers to normal weight babies (75.49%, SD 7.80) and that of low birth weight babies (76.55%, SD 7.78) also varied significantly at a p-value of 0.0176 at 95% C.I of 75.72%-77.38% with a mean difference of -1.06% and a standard error of 0.50. The mean FEV_1 of 83.53% (SD 10.30) and 84.32% (SD 9.62) respectively observed in mothers to normal birth weight and low birth weight, did not vary significantly. However, the mean difference was -0.79% with a standard error of 0.651. Table 6 below shows the summary of the mean differences of the lung functions together with

Birth outcomes	Rural (%)	95% CI	Urban (%)	95% CI	Total (%)	95% CI
Low birth weight	43.5	[39.3-47.7]	18.9	[16.2-21.9]	24.8	[22.5-27.3]
Preterm	7.9	[5.9-10.6]	5.2	[3.8-7.1]	5.9	[4.7-7.4]
Small for Gestational Age	55.1	[50.8-59.3]	21.3	[18.5-24.5]	29.5	[27.1-32.1]

Table 3: Showing proportions of adverse birth outcomes with their respective confidence intervals for rural and urban areas.

Factor	Group	Obs	Mean	Std. Err.	Std. Dev.	95% Conf.	Interval	P-value
Gestational Age	Rural	481	38.1684	0.0700015	1.535252	38.03085	38.30595	<0.001
	Urban	689	38.94194	0.0610658	1.602903	38.82205	39.06184	
	combined	1170	38.62393	0.0473658	1.62016	38.531	38.71686	
	diff		-0.773546	0.0936087		-0.9572057	-0.5898857	
Neonatal length	Rural	481	47.31601	0.2109482	4.626456	46.90151	47.7305	0.0926
	Urban	689	46.94775	0.1794335	4.709916	46.59545	47.30005	
	combined	1170	47.09915	0.1367425	4.677312	46.83086	47.36743	
	diff		0.368258	0.2778219		-0.1768279	0.9133438	
Neonatal weight	Rural	481	2.604366	0.0234998	0.5153899	2.558191	2.650541	<0.001
	Urban	689	3.00479	0.0211744	0.5558021	2.963215	3.046364	
	combined	1170	2.840171	0.0167875	0.5742194	2.807234	2.873108	
	diff		-0.400424	0.0320591		-0.4633235	-0.3375238	

Table 4: Showing mean differences of selected birth outcomes between rural and urban.

Factor	Group	Obs	Mean	Std. Err.	Std. Dev.	95% Conf.	Interval	P-value
FEV1/FVC	Rural	481	96.69	0.64	14.08	95.42	97.95	<0.0001
	Urban	687	104.2	0.43	11.22	103.4	105.1	
	Combined	1168	101.1	0.38	13.01	100.4	101.9	
	Diff		-7.53	0.74		-8.98	-6.07	
FVC	Rural	481	75.89	0.36	7.857	75.18	76.59	0.374
	Urban	689	75.74	0.3	7.767	75.16	76.32	
	Combined	1170	75.8	0.23	7.801	75.35	76.25	
	Diff		0.149	0.46		-0.76	1.059	
FEV1	Rural	481	84.75	0.44	9.706	83.88	85.62	0.003
	Urban	689	83.07	0.39	10.32	82.3	83.84	
	combined	1170	83.76	0.3	10.1	83.18	84.34	
	diff		1.684	0.6		0.51	2.859	

Table 5: Showing mean differences of Spirometry together with the standard error, standard deviations, and p-values at 95% confidence interval between rural and urban area.

Factor	Group	Obs	Mean	Std. Err.	Std. Dev.	95% Conf.	Interval	P-value
FEV_1/FVC	Normal Birth weight	830	101.5976	0.427273	12.30962	100.7589	102.4363	0.023
	LBW	338	99.92308	0.791262	14.54717	98.36664	101.4795	
	combined	1168	101.113	0.380752	13.01259	100.366	101.86	
	diff		1.674513	0.838557		0.029265	3.319762	
FVC	Normal Birth weight	831	75.49338	0.270441	7.796023	74.96255	76.02421	0.0176
	LBW	339	76.55162	0.422296	7.775292	75.72096	77.38228	
	combined	1170	75.8	0.228079	7.801494	75.35251	76.24749	
	diff		-1.05824	0.502032		-2.04323	-0.07326	
FEV_1	Normal Birth weight	831	83.53189	0.356849	10.2869	82.83146	84.23232	0.1127
	LBW	339	84.32153	0.523087	9.631057	83.29262	85.35045	
	combined	1170	83.76068	0.295379	10.10353	83.18115	84.34022	
	diff		-0.78964	0.650996		-2.0669	0.487607	

Table 6: Showing mean differences of Spirometry between mothers of low birth weight babies and normal weight.

Factor	Group	Obs	Mean	Std. Err.	Std. Dev.	95% Conf.	Interval	P-value
FEV_1/FVC	Normal for gestation age	757	102.4782	0.438582	12.06699	101.6172	103.3392	<0.0001
	SGA	411	98.59854	0.703985	14.27199	97.21467	99.98241	
	combined	1168	101.113	0.380752	13.01259	100.366	101.86	
	Diff		3.879663	0.789498		2.330668	5.428659	
FVC	Normal for gestation age	758	75.6372	0.284314	7.827671	75.07907	76.19534	0.1666
	SGA	412	76.09951	0.381995	7.753646	75.34861	76.85042	
	combined	1170	75.8	0.228079	7.801494	75.35251	76.24749	
	Diff		-0.46231	0.477528		-1.39922	0.474598	
FEV_1	Normal for gestation age	758	83.27836	0.371111	10.21734	82.54984	84.00689	0.0134
	SGA	412	84.64806	0.484847	9.841316	83.69497	85.60115	
	combined	1170	83.76068	0.295379	10.10353	83.18115	84.34022	
	Diff		-1.36969	0.617384		-2.581	-0.15839	

Table 7: Showing mean differences of Spirometry between mothers to SGA and mothers to normal babies.

the standard error, standard deviations, and p-values at 95% confidence interval between normal birth weight mothers and low birth weight mothers.

The mean differences were statistically significant between LBW and normal weight for FEV_1/FVC (p value 0.023) and FVC (p value=0.0176).

Mean differences of lung functions between mothers of SGA and of normal for gestational age babies

The mean FEV_1/FVC of mothers to normal for gestational age babies (102.50%, SD 12.10) and mothers to SGA babies (98.60%, SD 14.27) varied significantly with a p-value of < 0.0001 at 95% C.I of 100.37% - 101.86%. The mean difference was 3.88% with a standard error of 0.79. The mean FVC for mothers of normal for gestational age babies (75.64%, SD 7.83) and that of SGA babies (76.10%, SD 7.75) did not vary significantly. However, there was a mean difference of -0.46% at a standard error of 0.48. The mean FEV_1 of 83.28% (SD 10.22) and 84.65% (SD 9.84) respectively observed in mothers of normal for gestational age babies and SGA babies, varied significantly with a p-value of 0.0134 at 95% CI of 83.18% - 84.37. The mean difference was -1.37% at a standard error of 0.62. **Table 7** below shows the summary of the mean differences of the lung functions together with the standard error, standard deviations, and p-values at 95% confidence interval between mothers for normal gestational age babies and SGA babies.

The mean differences were statistically significant between SGA and normal for gestational age for FEV_1/FVC (p value<0.0001) and FEV_1 (p value=0.0134).

Mean differences of lung functions between mothers of preterm and mothers of full term babies

The mean FEV_1/FVC of 101.01% (SD 12.85) and 102.72% (SD 15.2)

Factor	Group	Obs	Mean	Std. Err.	Std. Dev.	95% Conf.	Interval	P-value
FEV_1/FVC	Full term baby	1094	101.0046	0.38863	12.8542	100.242	101.7671	0.1368
	PTB	74	102.7162	1.763772	15.17254	99.20102	106.2314	
	combined	1168	101.113	0.380752	13.01259	100.366	101.86	
	Diff		-1.71165	1.562872		-4.778	1.35471	
FVC	Full term baby	1096	75.74635	0.234682	7.769363	75.28587	76.20683	0.1828
	PTB	74	76.59459	0.962249	8.27758	74.67683	78.51235	
	combined	1170	75.8	0.228079	7.801494	75.35251	76.24749	
	Diff		-0.84824	0.937094		-2.68682	0.990331	
FEV_1	Full term baby	1096	83.80201	0.306092	10.13345	83.20141	84.4026	0.2953
	PTB	74	83.14865	1.127011	9.694911	80.90252	85.39478	
	combined	1170	83.76068	0.295379	10.10353	83.18115	84.34022	
	Diff		0.653359	1.213883		-1.72828	3.034993	

Table 8: Showing mean difference of Spirometry between mothers to preterm and mothers to full term babies.

	Rural						
	Normal birth weight		Low birth weight		Total		P-value
	%	95% CI	%	95% CI	%	95% CI	
Cough	81.3	[76.4-85.3]	77	[71.1-82.1]	79.4	[75.7-82.7]	0.238
Sputum	48.2	[42.5-53.9]	47.8	[41.4-54.4]	48	[43.8-52.3]	0.943
Wheezing	32	[26.9-37.5]	35.9	[29.9-42.3]	33.7	[29.7-37.9]	0.35
Breathlessness	17	[13.1-21.7]	17.7	[13.3-23.2]	17.3	[14.3-20.8]	0.827
Nasal	41.2	[35.7-46.9]	40.2	[34.0-46.7]	40.7	[36.6-45.0]	0.82
Throat	36.2	[30.9-41.8]	37.8	[31.7-44.3]	36.9	[32.8-41.1]	0.701
	Urban						
Cough	69.6	[65.7-73.2]	66.2	[57.8-73.6]	68.9	[65.4-72.2]	0.438
Sputum	46.7	[42.7-50.8]	39.2	[31.3-47.7]	45.3	[41.7-49.0]	0.117
Wheezing	28.8	[25.3-32.6]	31.5	[24.3-39.9]	29.3	[26.1-32.8]	0.53
Breathlessness	16.6	[13.8-19.9]	13.1	[8.4-19.9]	16	[13.5-18.8]	0.21
Nasal	46	[41.9-50.1]	52.3	[43.9-60.6]	47.2	[43.5-50.8]	0.185
Throat	30.4	[26.8-34.3]	36.9	[29.2-45.4]	31.6	[28.3-35.1]	0.143

Table 9: Association between low birth weight and maternal respiratory symptoms in rural and urban areas.

respectively observed in mothers of full term babies and mothers of preterm babies did not vary significant (p-value 0.1368). However, there was a mean difference of -1.712% at a standard error of 1.56. The FVC had a mean of 75.75% (SD 7.77) among mothers of full term babies and 76.60% (SD 0.960) among mothers of preterm babies. The two means did not vary significantly (p-value 0.183). However, there was a mean difference of -0.85% at a standard error of 0.94. The mean FEV_1 of 83.80% (SD 10.13) and 83.14% (SD 9.70) respectively observed in mothers of full term babies and mothers of preterm babies did not vary significant (p-value 0.295) at 95% CI of 83.18% - 84.37%. There was however, a mean difference of 0.653% at a standard error of 1.21. **Table 8** below shows the summary of the mean differences of the lung functions together with the standard error, standard deviations, and p-values at 95% confidence interval between mothers of full term babies and mothers of preterm babies.

No statistically significant difference in lung functions between mothers with preterm delivery and term delivery.

Bivariate analysis

Association between maternal respiratory symptoms and low birth weight (Tables 9-11)

There was no significant association between maternal respiratory health and preterm delivery. (Tables 12 and 13).

There was no significant association between maternal respiratory health and small for gestational age.

Assessment of influence of gestational age on the relationship between lungs functions and birth outcomes (Table 14)

There was a statistically significant association between FEV_1/FVC and preterm in the urban (p value<0.0001) and small for gestational age (p value<0.0001) in the rural area for all the three trimesters.

Multivariate logistic regression

Impact of maternal respiratory health on birth outcomes (Table 15)

In the urban area, LBW was statistically associated with recurrent nasal symptoms OR [1.69 (95% C.I; 1.0-2.8)] and prolonged secretion of phlegm OR [0.58 (95% C.I; 0.3-1.0)]. Pregnant women presenting with recurrent nasal symptoms were 1.69 times more likely to have a LBW child compared to the pregnant women with no recurrent nasal symptoms. While pregnant women with prolonged secretion of phlegm were 0.58 times less likely to have a low birth weight.

There was a significant association between FVC and LBW in the rural area OR [0.09 (99% C.I; 0.0-0.4)], pregnant women with mild reduction were 0.09 times less likely to have LBW compared to those with severe reduction of FVC. Preterm delivery was statistically significantly associated with FVC OR [0.39 (99% C.I; 0.2-0.8)] in the entire study population, pregnant women with mild reduction in the FVC were 0.39 times less likely to have a preterm delivery compared to pregnant women with a severe reduction in FVC.

Results and Discussion

This is the first research in Zambia exploring the association

	Rural						
FEV_1/FVC							
<70	0.4	[0.1-2.4]	0.5	[0.1-3.1]	0.4	[0.1-1.6]	0.646
70	0.4	[0.1-2.4]	0		0.2	[0.0-1.4]	
>70	99.3	[97.3-99.8]	99.5	[96.9-99.9]	99.4	[98.2-99.8]	
FEV_1							
Mild Obstruction	35.3	[30.0-40.9]	32.5	[26.7-38.9]	34.1	[30.1-38.3]	0.51
Normal	64.7	[59.1-70.0]	67.5	[61.1-73.3]	65.9	[61.7-69.9]	
FVC							
Moderate Reduction	29.8	[24.8-35.3]	25.8	[20.6-31.9]	28.1	[24.4-32.1]	0.337
Mild Reduction	35.7	[30.4-41.3]	33.5	[27.6-39.9]	34.7	[30.7-38.9]	
Normal	34.6	[29.3-40.2]	40.7	[34.5-47.2]	37.2	[33.2-41.5]	
Urban							
FEV1/FVC							
<70	0.9	[0.4-2.1]	0		0.7	[0.3-1.7]	0.269
70	0		0		0		
>70	99.1	[97.9-99.6]	100		99.3	[98.3-99.7]	
FEV_1							
Moderate obstruction	1.4	[0.7-2.8]	1.5	[0.4-5.8]	1.5	[0.8-2.6]	0.513
Mild Obstruction	40.8	[36.9-44.8]	35.4	[27.8-43.8]	39.8	[36.2-43.4]	
Normal	57.8	[53.7-61.7]	63.1	[54.6-70.8]	58.8	[55.1-62.3]	
FVC							
Moderate Reduction	27.5	[24.1-31.3]	22.3	[16.1-30.1]	26.6	[23.4-29.9]	0.321
Mild Reduction	38.5	[34.6-42.5]	37.7	[29.9-46.2]	38.3	[34.8-41.9]	
Normal	34	[30.2-37.9]	40	[32.1-48.5]	35.1	[31.7-38.7]	

Table 10: Association between maternal lung function and low birth weight.

Lung function	Rural						
	Preterm birth %		**Term birth 95% CI**		**Total %**		**P-value 95% CI**
FEV_1/FVC							
<70	0.5	[0.1-3.0]	0.4	[0.1-2.4]	0.4	[0.1-1.6]	0.506
70	0.5	[0.1-3.0]	0	-	0.2	[0.0-1.4]	
>70	99.1	[96.6-99.8]	99.6	[97.6-99.9]	99.4	[98.2-99.8]	
FEV_1							
Mild Obstruction	35.2	[29.3-41.5]	33.2	[28.0-38.9]	34.1	[30.1-38.3]	0.635
Normal	64.8	[58.5-70.7]	66.8	[61.1-72.0]	65.9	[61.7-69.9]	
FVC							
Moderate Reduction	28.2	[22.8-34.3]	27.9	[23.0-33.4]	28.1	[24.4-32.1]	0.98
Mild Reduction	34.3	[28.5-40.6]	35.1	[29.8-40.8]	34.7	[30.7-38.9]	
Normal	37.5	[31.5-43.9]	37	[31.6-42.7]	37.2	[33.2-41.5]	
Urban							
FEV1/FVC							
<70	0.8	[0.3-1.8]	0	-	0.7	[0.3-1.7]	0.233
70	0		0	-	-	-	-
>70	99.2	[98.2-99.7]	100	-	99.3	[98.3-99.7]	-
FEV_1							
Moderate Obstruction	1.5	[0.7-2.9]	1.4	[0.3-5.2]	1.5	[0.8-2.6]	-
Mild Obstruction	41	[37.0-45.1]	35.4	[28.2-43.3]	39.8	[36.2-43.4]	0.446
Normal	57.6	[53.4-61.6]	63.3	[55.3-70.5]	58.8	[55.1-62.3]	-
FVC							
Moderate Reduction	27.7	[24.1-31.5]	22.4	[16.5-29.8]	26.6	[23.4-29.9]	-
Mild Reduction	37.5	[33.5-41.5]	41.5	[33.9-49.5]	38.3	[34.8-41.9]	0.408
Normal	34.9	[31.0-38.9]	36.1	[28.8-44.0]	35.1	[31.7-38.7]	-

Table 11: Showing association between preterm birth and maternal lung functions.

	Rural						
	Normal		**SGA**		**Total**		**P-value**
	%	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	
Cough	81	[75.5-85.5]	78.1	[73.0-82.5]	79.4	[75.7-82.7]	0.414
Sputum	49.5	[43.2-55.9]	46.8	[41.1-52.6]	48	[43.8-52.3]	0.533
Wheezing	31.5	[25.9-37.7]	35.5	[30.1-41.2]	33.7	[29.7-37.9]	0.964

Breathlessness	17.2	[12.9-22.6]	17.4	[13.4-22.2]	17.3	[14.3-20.8]	0.7
Nasal	41.7	[35.5-48.1]	40	[34.5-45.8]	40.7	[36.6-45.0]	0.59
Throat	38.1	[32.1-44.5]	35.8	[30.5-41.6]	36.9	[32.8-41.1]	0.912
Urban							
Cough	69.4	[65.4-73.1]	67.3	[59.5-74.3]	68.9	[65.4-72.2]	0.632
Sputum	45.6	[41.5-49.7]	44.2	[36.5-52.2]	45.3	[41.7-49.0]	0.766
Wheezing	28.2	[24.7-32.1]	33.3	[26.3-41.2]	29.3	[26.1-32.8]	0.22
Breathlessness	17	[14.1-20.3]	12.2	[7.9-18.5]	16	[13.5-18.8]	0.158
Nasal	46.5	[42.4-50.6]	49.7	[41.8-57.5]	47.2	[43.5-50.8]	0.488
Throat	31	[27.3-34.9]	34	[26.9-41.9]	31.6	[28.3-35.1]	0.477

Table 12: Showing association between small for gestational age and maternal respiratory health.

	Rural						
Lung functions	**Norma**		**SGA**		**Total**		**P-value**
	%	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	
FEV_1/FVC							
<70	0.5	[0.1-3.0]	0.4	[0.1-2.4]	0.4	[0.1-1.6]	0.646
70	0.5	[0.1-3.0]	0		0.2	[0.0-1.4]	
>70	99.1	[96.6-99.8]	99.6	[97.6-99.9]	99.4	[98.2-99.8]	
FEV_1							
Mild Obstruction	35.2	[29.3-41.5]	33.2	[28.0-38.9]	34.1	[30.1-38.3]	0.446
Normal	64.8	[58.5-70.7]	66.8	[61.1-72.0]	65.9	[61.7-69.9]	
FVC							
Moderate Reduction	28.2	[22.8-34.3]	27.9	[23.0-33.4]	28.1	[24.4-32.1]	0.337
Mild Reduction	34.3	[28.5-40.6]	35.1	[29.8-40.8]	34.7	[30.7-38.9]	
Normal	37.5	[31.5-43.9]	37	[31.6-42.7]	37.2	[33.2-41.5]	
Urban							
FEV_1/FVC							
<70	0.9	[0.4-2.1]	0		0.7	[0.3-1.7]	0.233
70	0		0		0		
>70	99.1	[97.9-99.6]	100		99.3	[98.3-99.7]	
FEV_1							
Moderate obstruction	1.5	[0.7-2.9]	1.4	[0.3-5.2]	1.5	[0.8-2.6]	0.446
Mild Obstruction	41	[37.0-45.1]	35.4	[28.2-43.3]	39.8	[36.2-43.4]	
Normal	57.6	[53.4-61.6]	63.3	[55.3-70.5]	58.8	[55.1-62.3]	
FVC							
Moderate Reduction	27.7	[24.1-31.5]	22.4	[16.5-29.8]	26.6	[23.4-29.9]	0.313
Mild Reduction	37.5	[33.5-41.5]	41.5	[33.9-49.5]	38.3	[34.8-41.9]	
Normal	34.9	[31.0-38.9]	36.1	[28.8-44.0]	35.1	[31.7-38.7]	

Table 13: Showing association between small for gestational age and maternal lung functions.

	Low Birth weight											
	Rural-Masaiti						Urban - Ndola					
	OR	**SE**	**SD**	**[95% C.I]**		**P-value**	**OR**	**SE**	**SD**	**[95% C.I]**		**P-value**
FEV1												
1st trimester	1.019	0 .012	1.69	0.997	1.042	0.091	1.016	0.013	1.31	0.992	0.992	0.19
_cons	0.161	0.149	1.97	0.026	0.995	0.049	0.061	0.063	2.73	0.008	0.457	0.006
2nd trimester	1.019	0.012	1.69	0.997	1.042	0.091	1.017	0.013	1.37	0.993	1.042	0.172
_cons	0.174	0.153	1.98	0.031	0.984	0.048	0.062	0.06	2.86	0.009	0.42	0.004
3rd trimester	1.019	0.011	1.69	0.997	1.042	0.091	1.017	0.013	1.37	0.993	1.042	0.173
_cons	0.21	0.162	2.02	0.046	0.955	0.044	0.074	0.063	3.07	0.014	0.391	0.002
FVC												
1st trimester	1	0.009	0.03	0.983	1.018	0.979	1.006	0.009	0.7	0.989	1.024	0.486
_cons	0.752	0.62	0.35	0.148	3.806	0.73	0.133	0.108	2.49	0.027	0.652	0.013
2nd trimester	1	0.009	0.03	0.983	1.018	0.979	1.006	0.009	0.7	0.989	1.024	0.486
_cons	0.752	0.594	0.36	0.159	3.55	0.719	0.136	0.106	2.57	0.03	0.623	0.01
3rd trimester	1	0.009	0.03	0.983	1.018	0.979	1.006	0.009	0.7	0.989	1.024	0.486
_cons	0.754	0.528	-0.4	0.191	2.983	0.687	0.145	0.099	2.82	0.038	0.557	0.005
FEV_1/FVC												
1st trimester	0.989	0.006	1.74	0.977	1.001	0.083	1.022	0.012	1.85	0.999	1.045	0.064
_cons	2.416	1.605	1.33	0.655	8.91	0.185	0.022	0.028	2.95	0.002	0.277	0.003
2nd trimester	0.989	0.006	1.74	0.977	1.001	0.083	1.022	0.012	1.85	0.999	1.045	0.064
_cons	2.31	1.476	1.31	0.659	8.104	0.19	0.023	0.029	2.99	0.002	0.276	0.003

3rd trimester	0.989	0.006	1.74	0.977	1.001	0.083	1.022	0.012	1.85	0.999	1.045	0.064
_cons	2.311	1.476	1.31	0.659	8.104	0.19	0.029	0.033	3.11	0.003	0.272	0.002
Preterm birth												
	OR	SE	SD	[95% C.I]		P-value	OR	SE	SD	[95% C.I]		P-value
FEV_1												
1st trimester	1.017	0.022	0.76	0.974	1.061	0.45	1.011	0.023	0.48	0.967	1.057	0.631
_cons	0.022	0.04	2.11	0.001	0.769	0.035	0.022	0.042	2.01	5.00E-04	0.924	0.045
2ndtrimester	1.017	0.022	0.76	0.974	1.061	0.45	1.011	0.023	0.48	0.967	1.057	0.633
_cons	0.238	0.048	2.18	0.001	0.693	0.03	0.023	0.042	2.08	7.00E-04	0.804	0.037
3rd trimester	1.017	0.022	0.76	0.974	1.06	0.45	1.011	0.023	0.47	0.966	1.057	0.641
_cons	0.028	0.042	2.38	0.002	0.534	0.018	0.027	0.042	2.31	0.001	0.582	0.021
FVC												
1st trimester	0.989	0.015	0.76	0.961	1.018	0.45	0.994	0.017	0.35	0.962	1.027	0.727
_cons	0.235	0.315	1.08	0.017	3.263	0.28	0.093	0.14	1.58	0.005	1.78	0.115
2nd trimester	0.989	0.015	0.76	0.961	1.018	0.45	0.994	0.017	0.35	0.962	1.028	0.727
_cons	0.225	0.288	1.17	0.018	2.781	0.244	0.091	0.13	1.67	0.005	1.524	0.095
3rd trimester	0.989	0.015	0.76	0.961	1.018	0.45	0.994	0.017	0.35	0.962	1.027	0.727
_cons	0.201	0.228	1.41	0.022	1.865	0.158	0.086	0.109	1.94	0.007	1.034	0.053
FEV_1/FVC												
1st trimester	0.984	0.011	1.41	0.962	1.01	0.16	1.068	0.018	3.94	1.034	1.103	<0.0001
_cons	0.441	0.513	-0.7	0.045	4.32	0.481	3.00E-05	6.00E-05	5.27	7.00E-07	0.002	<0.0001
2ndtrimester	0.984	0.011	1.41	0.962	1.01	0.16	1.068	0.018	3.94	1.033	1.103	<0.0001
_cons	0.414	0.462	0.79	0.046	3.704	0.429	4.00E-05	8.00E-05	5.32	1.00E-06	0.002	<0.0001
3rd trimester	0.984	0.011	1.41	0.962	1.006	0.16	1.068	0.018	3.94	1.033	1.103	<0.0001
_cons	0.352	0.353	1.04	0.049	2.523	0.298	8.00E-05	1.00E-04	5.45	3.00E-06	0.002	<0.0001
Small for Gestational Age												
	OR	SE	SD	[95% C.I]		P-Value	OR	SE	SD	[95% C.I]		P-value
FEV_1												
1st trimester	1.005	0.011	0.45	0.983	1.027	0.655	1.01	0.012	0.85	0.987	1.033	0.395
_cons	0.814	0.751	0.22	0.132	4.99	0.823	0.12	0.116	-2.2	0.018	0.797	0.028
2nd trimester	1.005	0.011	0.45	0.983	1.027	0.655	1.01	0.012	0.91	0.988	1.034	0.365
_cons	0.83	0.729	0.21	0.148	4.664	0.832	0.119	0.109	2.32	0.02	0.02	0.021
3rd trimester	1.005	0.011	0.45	0.983	1.027	0.655	1.01	0.012	0.9	0.988	1.034	0.368
_cons	0.873	0.669	0.18	0.194	3.938	0.859	0.133	0.106	2.52	0.027	0.64	0.012
FVC												
1st trimester	1.002	0.009	0.24	0.985	1.02	0.809	1.015	0.009	1.68	0.998	1.032	0.093
_cons	1.005	0.831	0.01	0.198	5.104	0.995	0.072	0.058	-3.3	0.015	0.345	0.001
2nd trimester	1.002	0.009	0.24	0.985	1.02	0.809	1.015	0.009	1.68	0.998	1.033	0.093
_cons	1.014	0.802	0.02	0.214	4.797	0.986	0.077	0.058	3.37	0.017	0.342	0.001
3rd trimester	1.002	0.009	0.24	0.985	1.02	0.809	1.015	0.009	1.68	0.998	1.032	0.093
_cons	1.037	0.726	0.05	0.262	4.109	0.959	0.089	0.06	3.59	0.024	0.334	<0.001
FEV_1/FVC												
1st trimester	0.974	0.006	3.98	0.962	0.987	<0.0001	1.014	0.01	1.37	0.994	1.034	0.17
_cons	17.79	12.03	4.26	4.713	67.17	<0.0001	0.059	0.066	2.52	0.006	0.535	0.012
2nd trimester	0.974	0.006	3.98	0.962	0.987	<0.0001	1.014	0.01	1.37	0.994	1.034	0.17
_cons	16.03	10.43	4.27	4.469	57.53	<0.0001	0.062	0.067	2.56	0.007	0.523	0.011
3rd trimester	0.974	0.006	3.98	0.962	0.987	<0.0001	1.014	0.01	1.37	0.994	1.034	0.17
_cons	12.36	7.238	4.29	3.912	39.07	<0.0001	0.071	0.07	2.68	0.01	0.493	0.007

Table 14: Showing association between maternal lung functions in different trimesters and birth outcomes for rural and urban areas.

	Rural			Urban			Study population		
Factor	**LBW**	**PTD**	**SGA**	**LBW**	**PTD**	**SGA**	**LBW**	**PTD**	**SGA**
Mild Reduction (FVC 70-79)	0.09***	-	-	-	-	-	-	0.39***	-
	(0.0 - 0.4)							(0.2 - 0.8)	
Had recurrent nasal Symptoms last 12 months	-	-	-	1.69** (1.0 - 2.8)	-	-	-	-	-
Had prolonged(>month) secretion of phlegm	-	-	-	0.58** (0.3 - 1.0)	-	-	-	-	-
ciEform in parenthese* p<0.1 *** p<0.01 ** p<0.05									

Table 15: Showing association between maternal respiratory health and birth outcomes in the multivariate analysis.

between pregnancy- related outcomes and maternal respiratory symptoms and lung functions among both rural and urban pregnant women. The current study found that impaired lung function is linked to biomass fuel smoke and this is supported by results of a study in Ethiopia that found that exposure to indoor air pollution has been linked with a reduction of forced vital capacity and an increased risk of acute respiratory problems [14]. In the urban area, LBW was statistically associated with recurrent nasal symptoms and prolonged secretion of phlegm. Pregnant women presenting with recurrent nasal symptoms were 1.69 times more likely to have a LBW child compared

to the pregnant women with no recurrent nasal symptoms. While pregnant women with prolonged secretion of phlegm were 0.58 times less likely to have a low birth weight. Respiratory ill health has been cited in another study as being associated with adverse pregnancy outcomes. This study observed that the prevalence of adverse birth outcome is high among women with poor respiratory health. This finding is in line with the results of other researchers who also found that mothers with acute respiratory infectious diseases (ARID) during pregnancy had a longer gestational age at delivery than mothers without ARID [17]. Other studies elsewhere also observed that women who presented with asthma like symptoms of wheezing and breathlessness had a high prevalence of adverse birth outcomes for instance a study among Australian population showed that asthma in pregnancy is associated with increased poor outcomes for the mother and neonate and these poor outcomes include preterm birth, small for gestational age and preterm labor [18]. Similarly, Kallen and colleagues [19] also observed that the pregnancies of women with asthma are more likely to be complicated by preterm birth, lower birth weight and pre-eclampsia than pregnancies in non-asthmatic women [20].

This study found that there was a statistically significant association between FVC and LBW in the rural area. Pregnant women with mild reduction in FVC were 0.09 times less likely to have LBW compared to those with severe reduction of FVC. This is in accord with the findings in another study where low rates of fetal growth were observed in reduced lung function in adults [21] and a positive linear trend has been recorded between adult lung function and birth weight after adjusting for maternal factors [12]. Other findings elsewhere however, reported association of FEV_1 and LBW and observed that a direct relationship between maternal FEV_1 during pregnancy and infant birth weight [22]. Low FEV_1 has also been reported to be associated with preterm delivery by Odegaard and colleagues [23]. However, in our current study preterm delivery was significantly associated with FVC and pregnant women with mild reduction in the FVC were 0.39 times less likely to have a preterm delivery compared to pregnant women with a severe reduction in FVC. Our findings in this study showed that the gestational age of the pregnant women did not alter lung functions of the pregnant women. This agrees with findings in previous studies of impact of pregnancy on pulmonary function, results obtained by forced Spirometry, showed largely that forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), and peak expiratory flow (PEF) remain unchanged during pregnancy [14].

Conclusion

Maternal respiratory health had an influence on the adverse birth outcomes of pregnant women. Therefore, pregnant women with respiratory disease need frequent monitoring of respiratory symptoms and simultaneously conducting spirometry to help optimize their respiratory health throughout pregnancy.

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