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Maternal Smoking Affects Infant Mortality in Indonesia: Fact or Myth?

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Abstract*—This study addresses an important issue regarding infant mortality in Indonesia. This paper aims to investigate the impact of maternal smoking on infant mortality in Indonesia, as controlled by other maternal factors and socioeconomic variables. Using survival analysis, the results showed that maternal smoking significantly affects infant mortality ($p < 0.05$). Including control variables, a mother who exposes her infant to secondhand smoke increases the risk of infant mortality by 62.8 percent (Hazard Ratio = 1,628) compared to an unexposed infant. This study supports health policy initiatives to reduce the number of individuals who smoke and regulate other tobacco-related policies.

***Keywords*—Maternal smoking, infant mortality, passive smoking, exposure, survival analysis, tobacco, and cox regression**

I. INTRODUCTION

Sustainable development is not only oriented towards economic growth but must also be people-oriented (people-centered development) [1]. Therefore, people must be able to be healthy, educated, and safe.

Health is a substantial part of sustainable development. One indicator of health condition is the infant mortality rate (IMR). Based on data from Statistical Indonesia [2], IMR in Indonesia over the past five decades has been decreasing, but it is still relatively higher than in other Southeast Asian countries. In 2012, the IMR in Indonesia was 34 per 1000 live births.

Children represent the human capital of the future, and a high infant mortality rate is an indicator of poor health conditions in a country. Many studies on infant mortality have been conducted in Indonesia, especially focusing on health services and environmental aspects. However, further research on the survival of infants, particularly on the association with maternal smoking, is still limited. Therefore, there is a need for studying the impact of maternal smoking on infant mortality.

Based on the literature, maternal smoking is related to such issues as sudden infant death syndrome [3, 4], low birth weight [5-7] child respiratory diseases [8, 9], and childhood mortality [10, 11]. This study focuses on infant mortality as a result of exposure to maternal smoking and aims to investigate the impact of maternal smoking on infant mortality.

This study the risk of infant mortality related to exposure to secondhand tobacco from the mother is also influenced by maternal factors and socioeconomic variables. The questions addressed in this study are: (1) does maternal smoking impact infant mortality in Indonesia and (2) if maternal smoking impacts infant mortality in Indonesia, are there other maternal factors and socioeconomic variables as control variables? The data from the 2012 Indonesia Demographic and Health Survey (DHS) was analyzed in this study.

This paper is organized as follows. First is the introduction, then the literature review. The research methodology is described in Section 3. Section 4 discusses the results, and Section 5 concludes.

II. LITERATURE REVIEW

Based on Mosley and Chen's analytical framework, the proximate determinants affecting infant mortality were maternal factors, environmental contamination, malnutrition, injury, and personal illness control. Socioeconomic determinants affect infant mortality through the proximate determinants (Figure 1). The proximate determinants are as follows [12]:

- Maternal factors, including age, parity, and birth interval.
- Environmental contamination, including of air, food, and water.
- Malnutrition, consisting of lack of calories, protein, vitamins, and minerals.
- Injury, both accidental and intentional.
- Personal illness control, consisting of prevention and treatment.

Maternal smoking is one of the maternal factors (as a proximate determinant) that influences infant mortality. Previous studies found that maternal smoking was associated with an increased risk of infant mortality [13, 14]. Smoking during pregnancy was importantly associated with infant mortality as it led to premature births and sudden infant death syndrome (SIDS) [15]. In addition, the mechanism of maternal smoking increasing the risk of SIDS was the nicotine in cigarettes, which have the potential risk of combining with toxin bacteria to have a lethal effect [16].

Infection and respiratory diseases as an impact of secondhand tobacco were also contributors to infant mortality [13]. Maternal smoking after delivery also increases the risk of infant mortality. Secondhand tobacco was dangerous because they come from side-stream smoke,

which is qualitatively more dangerous than mainstream smoke because of higher combustion temperatures when formed and because it is not filtered by cigarettes or by passive smokers' lungs [17]. Side-stream smoke contains higher concentrations of ammonia, benzene, nicotine, carbon monoxide, and carcinogens. The size of the particles allows them to be easily pulled deep into the lungs and cause respiratory problems [18]. Children aged up to two years are more at risk for respiratory diseases from secondhand tobacco because the immune system and lungs are still developing [19]. Moreover, if the mother smokes during pregnancy (prenatal), it will decrease the lung function of the child [7].

Previous studies found that maternal smoking affected perinatal mortality [6, 14] and that maternal smoking was associated with neonatal mortality [20]. However, contradicting findings showed that maternal smoking was not related to neonatal [13, 21], the main cause of which was premature birth [13]. This paradoxical finding was not consistent with other studies that found that maternal smoking may increase the risk of premature birth, which has a high risk of mortality.

In economic theory, health is related by uncertainty [22]. For instance, some smokers, whether active or passive smokers, live long healthy lives while others suffer from illness and do not live long lives. Health or illness as the outcome cannot be chosen; risk can only be minimized because various possibilities can occur and are related to the probability problem [23].

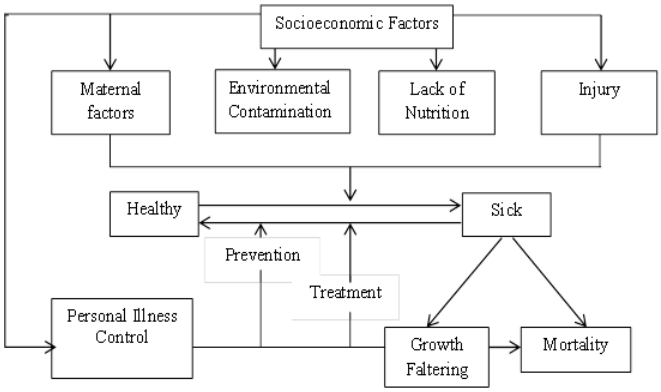

Fig. 1. Conceptual Model to Research on Child Survival
Source: Mosley & Chen, 1984

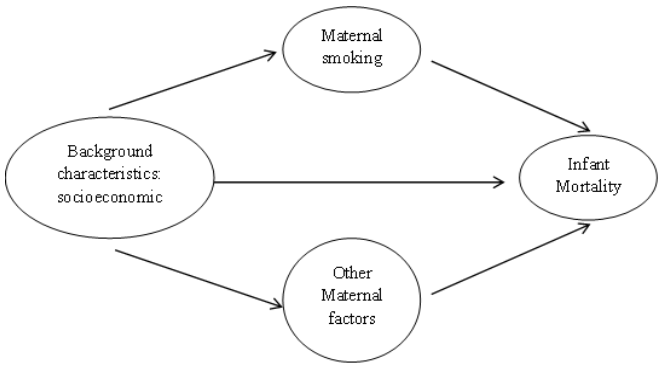

Fig. 2. Conceptual Model Examining the Influence of Maternal Smoking on Infant Mortality in Indonesia

Based on an analytical framework from Mosley and Chen [11] and other literature reviews, it is important to investigate the impact of maternal smoking on infant mortality in Indonesia. The impact of maternal smoking on infant mortality was also controlled by other maternal factors and socioeconomic variables. Accordingly, this study proposed that infant mortality was a function of maternal smoking, other maternal factors, and socioeconomic variables (Figure 2).

III. Research Methodology

A. Overview

Survival analysis was utilized to investigate the research question in this study. In this paper, maternal smoking was examined as the risk factor for infant mortality. The outcome variable, infant mortality (in months), is numeric. The outcome and independent variables were utilized in proportional hazard model (Cox regression).

B. Research Method

This study used a quantitative method and secondary data from DHS 2012. It was the latest published DHS data in Indonesia because the survey is held in Indonesia every five years. Data were collected using three types of the questionnaires: the household questionnaire, men's questionnaire, and women's questionnaire.

The infant was defined as a child up to 11 months of age. In this case, the unit for analysis is all births by women aged 15 to 49 years over the last five years before the time of the survey.

The data of infant mortality is survival outcome data. It was a combination between binary outcome and time to event (in this case, the time from birth to death). Survival analysis is more suitable for application to infant mortality data because the association between exposure to maternal smoking and infant mortality is influenced by time [24].

C. Data Analysis

Data for the infants of women aged 15 to 49 years was comprised of 18,021 samples. Infant mortality is defined as death of an infant from birth until the eleventh month of life. The survival time for the infants who died was the age at death (in months). In another case, infants who were still alive at the time of the survey as censor using their current age (in months).

Data for the outcome variable was derived from women's questionnaire about infant's survival status. The infants who died within five years before the survey, their survival status was categorized as "dead". If the baby or child was still alive at the time of enumeration, their survival status was categorized as still alive. Data for the main independent variable was derived from the women's questionnaire about woman's smoking status. If a woman self-reported that she smokes cigarettes or other types of tobacco, she was then categorized as a smoker. Maternal smoking status was categorized into two categories: smoking and non-smoking.

Control variables include maternal factors and socioeconomic variables. Maternal factors used this paper were the maternal age at childbirth, sex of the child, child's

birth order, and preceding birth interval. Next, socioeconomic variables consist of maternal education, household wealth index, and area of residence.

Descriptive statistics used crosstabulation between the main independent variable and other control variables, as well as between the outcome variable and independent variable. It was used to describe the maternal smoking status and infant survival status by background characteristics (maternal factors and socioeconomic variables). Next, Cox regression model was used to investigate the relationship between independent and outcome variables. The first model used only the main independent variable (univariate model), used to investigate the influence of a main independent variable on outcome variables. The second one included all independent variables (multivariate model). It was used to investigate the influence of main independent variables controlled by other independent variables. All analysis in this paper used unweighted sample data from DHS 2012.

IV. RESULTS

A. Maternal Smoking

Table 1 shows the prevalence of smoking among woman by their background characteristics. The highest prevalence of maternal smoking by maternal age at childbirth was in women who gave birth at over 35 years of age. The prevalence of maternal smoking by sex the child was nearly the same between mothers of both boys and girls. Moreover, women with over six children formed the highest demographic for prevalence of maternal smoking by birth order. Women with first birth had the least prevalence of maternal smoking by birth interval.

TABLE 1. BACKGROUND CHARACTERISTICS ACCORDING TO MATERNAL SMOKING STATUS

Background Characteristics	All sample		Maternal smoking status			
			non-smoking		smoking	
	n	%	n	%	n	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Maternal age at child's birth						
< 20 years	2134	11.8	2063	96.7	71	3.3
20-35	9819	54.5	9549	97.3	270	2.7
above 35 years	6068	33.7	5863	96.6	205	3.4
Maternal education						
no education/primary	6134	34.0	5822	94.9	312	5.1
secondary	9489	52.7	9278	97.8	211	2.2
higher	2398	13.3	2375	99.0	23	1.0
Household wealth index						
poor	9068	50.3	8690	95.8	378	4.2
middle	3249	18.0	3174	97.7	75	2.3
rich	5704	31.7	5611	98.4	93	1.6
Residence						
rural	9851	54.7	9493	96.4	358	3.6
urban	8170	45.3	7982	97.7	188	2.3
Sex of child						
female	8663	48.1	8423	97.2	240	2.8
male	9358	51.9	9052	96.7	306	3.3
Birth order						
1	6520	36.2	6401	98.2	119	1.8
2-3	8261	45.8	8016	97.0	245	3.0
4-5	2324	12.9	2211	95.1	113	4.9
6+	916	5.1	847	92.5	69	7.5
Birth interval						
first birth	6553	36.4	6433	98.2	120	1.8
<= 24 months	1707	9.5	1623	95.1	84	4.9
25-36 months	1850	10.3	1762	95.2	88	4.8
above 36 months	7911	43.9	7657	96.8	254	3.2

B. Infant Mortality

The infant mortality rate of infants exposed to maternal smoking was higher than for those who were unexposed (Figure 3). The mortality rate of infants unexposed to maternal smoking was 30.8 per 1000 live births. Meanwhile, for infants exposed to maternal smoking, the mortality rate was 60.4 per 1000 live births. In other words, the mortality rate for exposed infants is nearly double that of unexposed infants.

In general, infant mortality mostly occurs for infants exposed to maternal smoking, born to women over 35 years of age who have no education or only primary education, from poor households, living in rural areas and with male child(ren), birth order of six and up, and fewer than 24 months birth interval on average (Table 2). Infant mortality tends to occur for infants born to mothers of low socioeconomic status.

Model 1 (univariate model) showed that maternal smoking significantly increased the risk of infant mortality. Hazard ratios estimated to investigate the relationship between infant mortality and independent variables. In the univariate model, the risk of infant death among infants exposed to maternal smoking was higher at 96.2 percent, relative to unexposed infants.

In Multivariate models (model 2) included controls for maternal factors and socioeconomic variables. In the model with maternal age at child's birth, maternal education, household wealth index, residence, sex of child, birth order, and birth interval, maternal smoking was associated with a significant 62.8 percent increase in the hazard ratio (HR= 1,628) of maternal smoking. Infants exposed to maternal smoking had a raised risk of infant mortality at 62.8 percent, relative to unexposed infants.

Most of the control variables were statistically significant. Household wealth index was not significant to assess the influence on infant mortality.

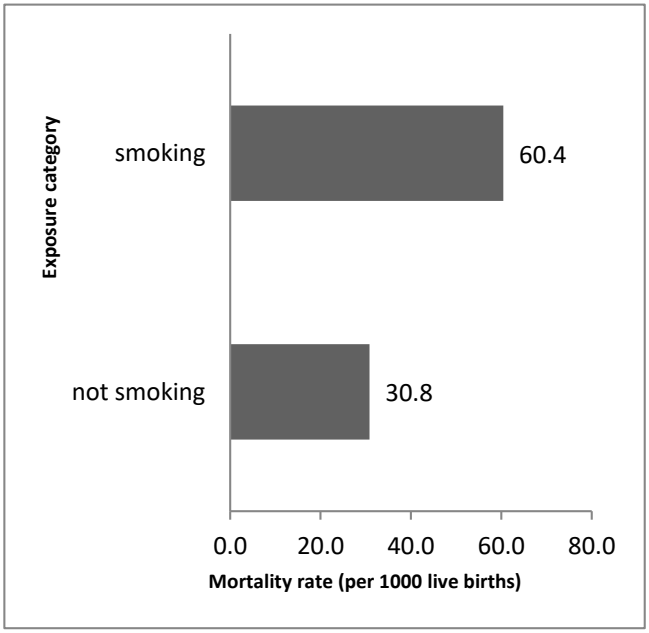

Fig. 3. Infant Mortality by Exposure Category

TABLE 2. BACKGROUND CHARACTERISTICS ACCORDING TO SURVIVAL STATUS

Background Characteristics	All samples		Survival status			
			still alive		deathdeceased	
	n	%	n	%	n	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Maternal smoking status						
not non-smoking	17475	97.0	16936	96.9	539	3.1
smoking	546	3.0	513	94.0	33	6.0
Maternal age at child's birth						
< 20 years	2134	11.8	2084	97.7	50	2.3
20–35	9819	54.5	9557	97.3	262	2.7
above 35 years	6068	33.7	5808	95.7	260	4.3
Maternal education						
no education/primary	6134	34.0	5868	95.7	266	4.3
secondary	9489	52.7	9222	97.2	267	2.8
higher	2398	13.3	2359	98.4	39	1.6
Household wealth index						
poor	9068	50.3	8717	96.1	351	3.9
middle	3249	18.0	3156	97.1	93	2.9
rich	5704	31.7	5576	97.8	128	2.2
Residence						
rural	9851	54.7	9478	96.2	373	3.8
urban	8170	45.3	7971	97.6	199	2.4
Sex of child						
female	8663	48.1	8431	97.3	232	2.7
male	9358	51.9	9018	96.4	340	3.6
Birth order						
1	6520	36.2	6310	96.8	210	3.2
2–3	8261	45.8	8042	97.3	219	2.7
4–5	2324	12.9	2236	96.2	88	3.8
6+	916	5.1	861	94.0	55	6.0
Birth interval						
first birth	6553	36.4	6338	96.7	215	3.3
<= 24 months	1707	9.5	1612	94.4	95	5.6
25–36 months	1850	10.3	1792	96.9	58	3.1
above 36 months	7911	43.9	7707	97.4	204	2.6

TABLE 3. HAZARD RATIO FOR RELATIONSHIP BETWEEN INFANT MORTALITY AND MATERNAL SMOKING WITH THE CONTROL VARIABLES

Independent Variables	Hazard Ratio			
	Model 1		Model 2	
(1)	(2)		(3)	
Maternal smoking status				
smoking	1.962	*	1.628	*
not non-smoking	1.000		1.000	
Maternal age at child's birth				
< 20 years			1.000	
20–35			1.731	*
above 35 years			3.731	*
Maternal education				
no education/ primary			1.000	
secondary			0.742	*
higher			0.382	*
Household wealth index				
poor			1.000	
middle			0.900	
rich			0.819	
Residence				
rural			1.000	
urban			0.771	*
Sex of child				
female			1.000	
male			1.354	*
Birth order				
1			1.000	
2–3			4.272	*
4–5			3.811	*
6+			4.076	
Birth interval				
first birth			1.000	
<= 24 months			0.256	
25–36 months			0.135	*
above 36 months			0.100	*

* p< 0.05

V. DISCUSSION

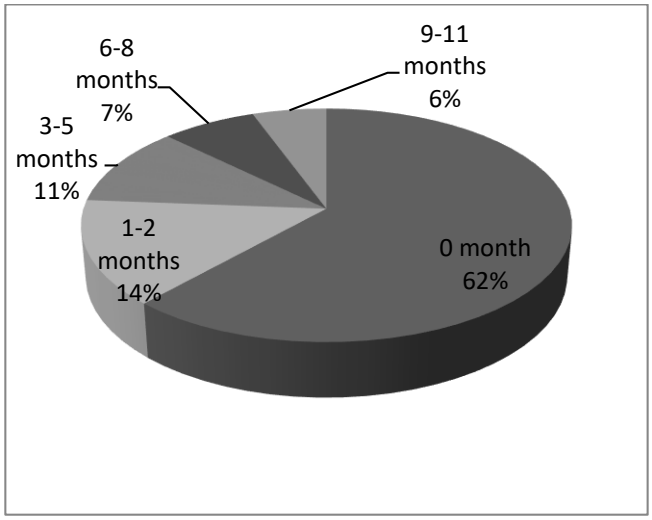

Fig. 4.. Infant Mortality by Age at Death (in months)

This study examined the relation between maternal smoking and infant mortality. The data suggest that infants exposed to secondhand smoke from their mothers were at higher risk of mortality. These findings were consistent with the previous study that found exposure to maternal smoking increased the risk of infant mortality [19, 25, 26]. This study found that infant mortality due to maternal smoking mostly occurred in infants born to mothers of low socioeconomic backgrounds.

The risk of infant death from maternal smoking was reduced after controlling for maternal factors and socioeconomic variables. It is important to note that even though the prevalence of maternal smoking for Indonesian woman was low, this study found that there was a relationship between maternal smoking and infant mortality, even after controlling for maternal factors and socioeconomic variables.

Figure 4 shows that the majority of infant death during the first year of life occurring in the first month (neonatal mortality). It can be indicated that one reason for increased neonatal mortality was maternal smoking. This finding consistent with other studies that found that smoking was related increased risk of neonatal mortality (Johansson et al., 2009) [19]. Maternal smoking was associated with infant death because it can increase the risk of SIDS (Sayers et al., 1995) [15].

Infant mortality also occurred in the post-neonatal period. Maternal smoking after delivery also contributed to the risk of post-neonatal mortality. Maternal smoking after delivery increases the risk of infant mortality because the child spends most of his time with his mother and would be exposed to secondhand smoke from the mother [27].

VI. CONCLUSION

Based on national samples from Indonesian women, this study found that maternal smoking was associated with higher risk of infant mortality. The most infant deaths occurred in the neonatal period. This study also found that infant mortality and maternal smoking mostly occurred for infants born to mothers of low socioeconomic status.

This study also has limitations. The outcome variable in this study, infant mortality, was a rare case. This study only focused on the risk of infant mortality due to maternal smoking, did not pay attention to the effects of maternal smoking on stillbirth and miscarriage. Other limitation, smoking status is a condition at the time of enumeration. The women's smoking status may actually change over time, but for the purposes of the analysis, the maternal smoking variable is assumed not to change.

The findings in this study need to be acted upon to reduce infant death. Besides providing health services, public health interventions should be taken to reduce the number of people who use tobacco. In addition, women need to be educated about the dangers of smoking, as it is not only dangerous for active smokers but also harms others, particularly infants and children.

Further research is expected to study the association between maternal smoking and stillbirth/miscarriage. The use of longitudinal data may be applicable to study the long-term effects of maternal smoking on child health outcome.

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