ORIGINAL RESEARCH ARTICLE

Inter-Pregnancy Intervals and Maternal Morbidity: New Evidence from Rwanda

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Abstract

The effects of short and long pregnancy intervals on maternal morbidity have hardly been investigated. This research analyses these effects using logistic regression in two steps. First, data from the Rwanda Demographic and Health Survey 2010 are used to study delivery referrals to District hospitals. Second, Kibagabaga District Hospital's maternity records are used to study the effect of inter-pregnancy intervals on maternal morbidity. The results show that both short and long intervals lead to higher odds of being referred because of pregnancy or delivery complications. Once admitted, short intervals were not associated with higher levels of maternal morbidity. Long intervals are associated with higher risks of third trimester bleeding, premature rupture of membrane and lower limb edema, while a higher age at conception is associated with lower risks. Poor women from rural areas and with limited health insurance are less often admitted to a hospital, which might bias the results. *(Afr J Reprod Health 2015; 19[3]: 77-86).*

Keywords: Inter-Pregnancy intervals, previous pregnancy, maternal morbidity, physiological regression, Rwanda

Résumé

Les effets des intervalles de grossesses courtes et longues sur la morbidité maternelle ont à peine été étudiés. Cette recherche analyse ces effets à l'aide de la régression logistique en deux étapes. Premièrement, les données de l'Enquête démographique et de la Santé du Rwanda de 2010 ont été utilisées pour étudier les orientations des accouchements dans les hôpitaux de district. Deuxièmement, les dossiers de maternité de l'Hôpital du district de Kibagabaga sont utilisés pour étudier l'effet des intervalles entre les grossesses sur la morbidité maternelle. Les résultats montrent que des intervalles courts et longs conduisent à de plus grandes chances d'être orientés à cause des complications de grossesse ou d'accouchement. Une fois admis, les intervalles courts ne sont pas associés à des niveaux plus élevés de morbidité maternelle. Les longs intervalles sont associés à des risques plus élevés de saignements de troisième trimestre, la rupture prématurée de la membrane et l'œdème des membres inférieurs, alors que la conception à un âge plus élevé est associée à moins de risques. Les femmes pauvres des zones rurales et qui avaient l'assurance maladie limitée sont moins souvent admises dans un hôpital, ce qui pourrait biaiser les résultats. *(Afr J Reprod Health 2015; 19[3]: 77-86).*

Mots-clés: intervalles entre les grossesses, grossesse précédente, morbidité maternelle, régression physiologique, Rwanda

Introduction

In Rwanda, the maternal mortality ratio has dropped impressively from 750 deaths per 100,000 women in 2005 to 383 in 2010, but needs to decline further to achieve the government's target of 268 deaths per 100,000 women in 2015[1-2]. The establishment of community health care and improved access to health facilities through a community based insurance system contributed to this improvement[3]. Further improving the quality of and access to health care will certainly help, but should be accompanied by a strategy to improve maternal health as such, not just for the sake of the mother but also for her child. Deteriorated physiological conditions of the mother during the gestation period are shown to have a negative impact on pregnancy outcome[4], and maternal morbidity is among the leading causes of perinatal mortality[5-7].

One way to improve maternal health may be to space successive pregnancies in such a way that the effects of the previous pregnancies are not carried into the next. A wide literature has shown the adverse outcomes of both short (less than two years) and long (more than five years) inter-pregnancy intervals (IPIs) for the next pregnancy, yet few studies have addressed the effect of IPIs on maternal morbidity.

The aim of this study is to analyze whether better spacing could contribute to better maternal health. The study consists of two parts. First, it analyzes the effect of the reproductive history (outcome of the previous pregnancy and the interval to the current pregnancy) on the odds of being referred to a district hospital for the delivery. Second, it uses hospital data to analyze the effects of this reproductive history on four indicators of maternal morbidity.

Relationships between IPI and maternal morbidity

Both short and long inter-pregnancy intervals are associated with an increased risk of maternal morbidity and mortality[8-9]. Possible explanations for the association between a short IPI and maternal morbidity are threefold. The first, which is widely debated in association with pregnancy complications, is maternal (nutritional) depletion due to inadequate time to restore vital resources as folate, iron and vitamins[10]. This counts for women in poor countries in particular, because many are undernourished. The second explanation is stress, given that providing care for and breastfeeding a young child during a pre-term next pregnancy is both physically and emotionally demanding. The third is insufficient time for the healing of genital injuries or for the hormonal recovery from the previous pregnancy and birth which is likely to affect the mother and index pregnancy[11]. The association between a long IPI and maternal morbidity is explained by physiological regression with subsequent risk of complications such as hypertension, (pre-) eclampsia and edema[8, 12-13]. However, the effect of long IPIs could be endogenous. Reduced fecundity at higher ages could lead to both longer intervals and pregnancy complications and without controlling for age the mechanism cannot be confirmed. Yet, a poor physiological status to give birth has also been put forward as a reason why primigravida have a higher risk of pregnancy complications and why maternal morbidity is high among the (very) young[14].

While many studies have focused on adverse effects of IPI duration on pregnancy- and perinatal outcomes, thus allowing meta-studies with significant numbers of entries, too few have studied the relationship between IPI length and specific pregnancy-related illnesses to do this in a systematic and scientific way[15]. The omission is partly due to the wide spectrum of maternal morbidity indicators that are used in existing studies[15], and to a lack of representative datasets that include both information on the core variables and important confounding factors. So far, three studies appropriately analyzed associations between IPI duration and hemorrhage (ante- or postpartum bleeding), premature rupture of membranes (PROM), hypertensive disorders, (pre-) eclampsia or proteinuria, uterine rupture, maternal infection, maternal anemia or lower limb edema (LLE) [12,16-18]. The results of these studies do not always support a clear association between IPI duration and a particular maternal morbidity. The need for more studies from different contexts is evident.

Another lesson to be learned from research on the effects of IPIs on pregnancy outcomes is that it should include the previous pregnancy as a possible confounding factor[19]. In particular in combination with a short IPI the type of previous outcome (early pregnancy loss versus surviving breastfed child) has a differential effect on the nutritional status of the mother[20-21]. There is already proof that induced or spontaneous pregnancy terminations in combination with a closely timed next pregnancy (IPI < 6 months) increase the risk of maternal anemia and PROM[22,12]. Unsafe abortions can even lead to genital sepsis and -injuries that will harm the mother's health during future pregnancies. Also a previous caesarean section in combination with a short IPI – like after an unsafe induced abortion - increases the risk of a premature uterine rupture and ante-partum bleedings caused by an incomplete healing of the uterine scar[23-24].

Methods

Two types of datasets are used in this study. The first is the latest Demographic and Health Survey (RDHS 2010), which covers 13,671 women in the age 15-49. This data set is used to depict which pregnant women have higher odds to be referred to district and referral hospitals due to pregnancy related complications (morbidity). In total 6325 women who had at least one pregnancy in the calendar period 2005-2010 are included in this first analysis. One out of 5 were pregnant for the first time, 17.4% were referred to a higher level health facility due to pregnancy complications. Table 1 presents the descriptive statistics from the variables for the analysis.

Table 1: Incidence of Referrals to District Hospitals in Rwanda

		Referred
Variable Name	Total N	Yes %
Inter-pregnancy interval		
IPI (24-59 months) -Ref	2264	8.9
Primigravida	1324	29.0
<=12 months	746	22.1
13-18 months	837	13.4
19-23 months	821	11.6
>=60 months	333	19.2
Age at Conception		
>=21 and <=35 Years -Ref	4614	18.1
<=20 Years	595	23.2
>=36 Years	1116	11.6
Previous delivery		
Live birth -Ref	5812	17.1
Pregnancy disruption	210	23.8
Infant death	303	18.5
Wealth Quintiles		
Upper two -Ref	2342	26.2
Middle	1217	14.7
Lower two	2766	11.2
Location health centers		
Other regions -Ref	5594	14.2
Kigali City	731	42.1
Total	6325	17.4

*Source: RDHS 2010/11

The percentages in table 1 show a wide variation in referrals. Women with healthy intervals are referred far less and primigravida and women with short and long intervals are referred more. Women from the wealthier quintiles and from Kigali show higher percentages of referral, yet it is hard to envisage that this would be a result of higher morbidity.

The second dataset is derived from the Kibagabaga District hospital files and is used to study specific gestation and delivery complications (maternal morbidity) among pregnant women who were transferred from health care centres located in the hospital's catchment area. The risk of pregnancy-induced illness is identified by the local health care centres' staff during the pregnant woman's visit for antenatal check-up or delivery. In total, hospital discharge files for 2500 women were studied. The files are filled in by Kibagabaga hospital staff and contain socio-demographic characteristics of the women (age, occupation, province, place of residence, type of insurance), reproductive history (number of previous live births, dead and living children, number of previous spontaneous abortions or stillbirths and premature births, last menstrual period) and reason of transfer or admission. Additional health complications of the mother such as her HIV/AIDS status and her eventual medical and surgical history, the estimated date of delivery are also registered on the hospital files. Not all files contained all additional information (missing values were classifies as 'not specified'). It can be assumed that these women partly were brought in as emergency cases, yet the quality of the record keeping is high. In only a few cases some information was missing. The timing of the previous birth could not be calculated for 156 patients. The only exception is the information on the health centre that referred patients to the hospital. Of the total set, 37.2% were transferred by health centres located in Kigali city, 39.2% from centres in the peri-urban areas surrounding Kigali city and for 23.6% of the women this information was missing. The reason for this large number of missing entries is that some patients go to the hospital directly. This is against procedures, but the maternity ward will not turn down patients that require medical assistance. We have included these cases as a separate category of not-specified in the analyses. The descriptive statistics of the variables in the analysis are listed in Table 2.

Table 2: Descriptive Statistics for Four Indicators of Maternal Morbidity

Variable names	N=2500	**Gestational** Hypertension (%)	**Third** Trimester Bleeding (%)	**Premature** Rupture of Membrane (%)	**Lower** Limb Edema (%)
Inter-pregnancy Interval					
IPI(24-59 months) Ref	395	6.6	22.8	26.8	3.1
Primigravida	1054	10.0	25.1	28.6	7.1
<=12 months	180	8.9	20.6	22.2	2.8
13-18 months	238	8.6	21.8	28.2	2.9
19-23 months	267	4.5	25.1	25.8	3.4
No IPI specified	156	9.0	21.2	23.7	5.1
>=60 months	210	2.4	29.5	32.9	5.7
Age at conception					
>=21 & <=35 years Ref	1888	7.5	24.3	27.0	4.2
<=20 years	421	8.8	23.8	28.0	2.1
(>=36 years)	191	8.9	24.6	30.6	5.8
Previous delivery					
Normal delivery Ref	1990	3.3	18.6	21.4	4.0
Adverse types of delivery	510	9.0	25.7	31.7	3.9
Medical Insurance					
Private (Ref)	405	4.4	25.4	27.4	2.7
Mutual	2052	8.5	24.2	27.5	4.3
Not specified	43	7.0	16.3	20.9	2.3
Place of residence					
Urban Ref	932	5.2	18.8	20.9	4.5
Peri-Urban	979	11.7	27.0	33.0	3.8
Not specified	589	5.6	28.4	28.4	3.6
Total/Average	2500	7.8	24.2	27.4	4.0

*****Source: Kibagabaga hospital obstetrical records, 2012-2013

Table 3: Effect of IPI on Pregnancy-Related Referrals to District Hospitals in Rwanda

		Primigravida included				**Multiparous only**			
Variable Names	N	B	S.E.	Sig.	Exp(B)	B	S.E.	Sig.	Exp(B)
Inter-pregnancy Interval									
>=24 & <=59 months-Ref	2264								
Primigravida	1324	**0.995**	**0.100**	***	**2.704**	n.a			
<=12 months	746	**0.513**	**0.113**	***	**1.670**	**0.351**	**0.123**	**	**1.420**
>=13 & <=18 months	837	0.055	0.123		1.056	0.016	0.124		1.016
>=19 & <=23 months	821	-0.041	0.129		0.959	-0.051	0.130		0.950
>=60 months	333	**0.432**	**0.160**	**	**1.540**	**0.430**	**0.161**	**	**1.537**
Age at conception									
21 thru 35 years-Ref	3753								
<=20 years	138	-0.229	0.120		0.795	0.257	0.227		1.293
>=36 years	1110	**-0.254**	**0.108**	*	**0.776**	**-0.288**	**0.111**	*	**0.750**
Previous delivery									
Live birth-Ref	4490	n.a							
Pregnancy loss	210	n.a				**0.505**	**0.187**	**	**1.658**
Infant death	301	n.a				**0.304**	**0.166**		1.355
Wealth Quintile									
Upper two -Ref	1816								
Middle	965	**-0.653**	**0.086**	***	**0.521**	**-0.722**	**0.103**	***	**0.486**
Lower two	2220	**-0.396**	**0.101**	***	**0.673**	**-0.382**	**0.119**	**	**0.683**
Place of Residence									
Other Regions-Ref	4483								
Kigali City	518	**1.057**	**0.096**	***	**2.877**	**1.139**	**0.113**	***	**3.122**

Constant	**-1.697**	**0.085**	********	**0.183**	**-1.712**	**0.091**	*******	**0.181**

*Significance level: *<0.05; **<0.01; ***<0.001
Source: RDHS 2010/2011

Table 4: Effect of Inter-Pregnancy Intervals on Pregnancy Related Morbidity

Variable name	N=2500	Gestational Hypertension Exp B	Sig.	Third Trimester Bleeding Exp B	Sig.	Premature Rupture of Membrane Exp B	Sig.	Lower Limb Edema Exp B	Sig.
Inter-pregnancy Interval									
24-59 months Ref	395								
Primigravida	1054	**1.709**	*	1.177		1.277		1.208	
<=12 months	180	1.375		0.876		0.910		0.679	
13-18 months	238	1.206		0.971		1.090		0.723	
19-23 months	267	0.690		1.155		1.058		0.842	
>=60 months	210	**0.332**	*	**1.451**	*	**1.343**	*	1.336	
No IPI specified	156	1.558		0.965		0.978		1.406	
Age at conception									
21 - 35 years (Ref)	1888								
<=20 years	421	0.984		0.939		0.942		**0.447**	**
>=36 years	191	1.461		0.953		1.063		1.474	
Previous type of delivery									
Normal (Ref)	1990								
Abortion/Caesarian	510	**3.164**	***	**1.303**	**	**1.394**	**	1.040	
Type of Insurance									
Private	405								
Mutual	2052	**1.894**	*	0.964		1.010		1.559	
Not Specified	43	1.777		0.493		0.486		0.842	
Location health center									
Urban (Ref)	932								
Peri-Urban	979	**2.482**	***	**1.610**	***	**1.703**	***	0.819	
Not specified	589	1.183		**1.746**	***	**1.614**	***	0.837	
Model Constant		0.023		0.218		0.264		0.032	

*Significance level: *<0.05; **<0.01; ***<0.001
Source: Kabagabaga hospital files 2012-2013

Table 2 Descriptive statistics for four indicators of maternal morbidity

The data shows that premature rupture of membrane and third trimester bleeding are the most common complications. Older mothers and the ones with longer intervals seem to have more complications. Strikingly, women from the city have fewer complications than those from peri-urban areas, which probably reflect differences in referrals. These differentials in referral (see table 1) raise a methodological issue. In a situation of unequal access to hospital care, the hospital data refer to a selective group within the total population of pregnant women and therefore the outcomes of the analyses may be biased. In the ideal situation one would prefer to estimate the odds of referral and the odds of complications simultaneously on the basis of one single dataset. Unfortunately such data is not available in Rwanda as the coverage and registration of antenatal care is incomplete. The second best solution, for which we opted, is to provide separate analyses of referral and morbidity, using the first to identify confounding factor to be included in the second and to more carefully interpret the outcomes on morbidity. More specifically, the analysis of the referrals on the RDHS data serves two purposes. The first is to see whether women with short or long interval have higher odds to be referred to the hospital, indicating that they have more complications or that the local health center perceives the risk of complication higher. The second is to identify the confounding effects of wealth and place of residence on the odds of being admitted to a hospital. The dependent variable is measured in the RDHS by the question "Where did you give birth to your last born child?" and we used the category "referral hospital" as opposed to all other categories.

Using binary logistic regression with the referral status as the dependent variable, two analyses are made. The first includes the nulliparous women, which means that the previous pregnancy outcome cannot be included in the model. The second is restricted to multiparous women and does include the outcome of the previous pregnancy as a predictor.

The dependent variables of the morbidity analyses are four maternal morbidity indicators indicated on the patient's file for the last pregnancy: gestational hypertension, pre-mature rupture of membranes (PROM), third trimester bleeding (TTB) and lower limb edema (LLE). These four maternal morbidity indicators relate to a severe maternal morbidity and are coded as binary (yes or no) in the 4 separate logistic regression models.

The main independent variables used in the logistic regression analyses are IPI and previous pregnancy outcome, when confounding factors as age of the mother, place of residence and type of health insurance are included. The IPI in the RDHS was measured as the interval (in months) between the conception of the last pregnancy and outcome of the previous pregnancy that ended either in a pregnancy disruption or a live birth. In the DHS women provide their reproductive history, in the so-called calendar. Starting from the last birth backward, she provides details on the month and year of each birth and death if the child did not survive to the time of the interview. Likewise, women who had experienced any pregnancy termination reported the month and year when this event happened. Using this information the last and the previous event could be timed and the interval defined by subtracting the dates. We used wealth and place of residence as proxies for access to referral hospital care. The referral hospitals are located in the (urban) centers of the districts in Rwanda and charge a contribution from their patients, as opposed to health centers that provide free care.

For the Kibagabaga dataset the IPI is measured as the time (in months) elapsed between the date of the preceding outcome (live birth, stillbirth, or miscarriage (induced or spontaneous) and the date of the last menstrual period before the current pregnancy. Intervals between the two last pregnancies were classified in accordance with the World Health Organization's recommendation, which considers an IPI of 24 to 59 months after a live birth before attempting to become again pregnant again is an ideal IPI for better maternal and neonatal outcomes. The shortest interval used here is within one year. The variable previous pregnancy outcome is classified as a binary variable: had previously experienced a normal delivery versus an adverse pregnancy outcome (prior caesarian section or pregnancy loss - including all types -, and premature birth). The Kibagabaga hospital is located in Kigali, but the catchment area extends into the peri-urban environment. The place of residence (urban/peri-urban) is used as a proxy for the distance to the hospital. The type of insurance is used as a proxy for the access to hospital services. Only 43 patients were admitted without some form of insurance.

Results

Effect of IPIs and previous pregnancy outcome on maternal referrals

Of the 5001 women with more than one pregnancy, 45% (Table 1) started their index pregnancies after a healthy interval of 24-59 months in the period 2005-2010. This interval is used as the reference category in our analyses and therefore listed in the first row. Nearly 15% was pregnant again within 12 months, 33% between 13 and 23 months, and only 6% after a long IPI (=> 60 months).

Table 3 presents the outcomes of 2 binary logistic regression analyses for the effects of IPI length on the odds of a maternal referral to a higher level health facility. The constant in the first model (which includes primigravida) presents the odds of referral for the reference category. Women who spaced their pregnancy in healthy intervals (24-59 months); aged between 21 and 35 years who are classified among rich and richest category and reside outside Kigali city show low odds of being referred (183 over 1000 which corresponds to a likelihood of being admitted of 15.5%). The odds for women who became pregnant again within a year are 1.67 times higher, compared to women who conceived after a healthy interval. For women with a long IPI (=>5 years) the odds ratio is 1.54.

Table 3: Effect of IPI on pregnancy-related referrals to District Hospitals in Rwanda

The odds ratio for mothers of over 35 years of age is smaller than 1, indicating that they are less referred than younger mothers. The highest odds ratio is found for women expecting a baby for the first time (odds ratio of 2.704). Women who spaced their pregnancies between 13 and 23 months don't show significant higher odds of being referred.

Women from the middle and lower wealth quintiles have significantly lower odds (0.521 and 0.673) to be sent to a hospital, other things being equal.). The model estimates that women from the middle quintile have a chance of less than 9% to be referred, compared to 18% for the more wealthy women.

Living in Kigali increases the odds to deliver in a hospital considerably, the odds are almost three times higher than for those who live outside Rwanda's capital.

When the variable outcome of the previous pregnancy is included in the model (see the second part of table 3) a new risk group emerges. Mothers who had a previous pregnancy loss (all types taken together) have significantly higher odds ratio of being referred.

The other coefficients in the table hardly change when primigravida are excluded and the outcome of the previous pregnancy is added as an independent variable. The only larger change is among the women younger than twenty who now have higher odds to be referred but the effect is not significant. All other variables have the same sign and comparable magnitudes. Women of less wealth have lower odds and women in Kigali have higher odds.

Effect of IPI and previous pregnancy outcome on maternal morbidity

Table 4 presents odds ratios from binary logistic regressions for each morbidity status. The constant of each model gives the odds of being diagnosed and treated for the four types of morbidity for the reference category; patients in the age 20-25 from Kigali City with private insurance that had a normal delivery before and a healthy interval. Their odds are low for gestational hypertension and LLE (odds 0.023 and 0.032), but higher for TTB (0.218) and PROM (0.264). Looking at the effects of the two main independent variables of interest (IPI and previous pregnancy outcome) it becomes clear that significant deviations from the reference group occur, yet the insignificant results are just as interesting.

Table 4: Effect of Inter-pregnancy Intervals on pregnancy related morbidity

The table shows that the effects of short intervals are all insignificant and that the odds ratios are close to one. Women with very short intervals seem to have higher odds of hypertension (ratio is 1.375) but even this one is not significant at the 0.05 level. Short intervals do not lead to more morbidity. Long intervals lead to substantially lower odds of hypertension (0.332) and to higher odds of bleeding, rupture and edema (odds ratios are 1.451, 1.343 and 1.336). Becoming pregnant at higher ages is not related to bleeding or rupture. The odds ratios are higher for hypertension and edema, but nog significant. The relation of higher age to maternal morbidity is clearly different from the relation of long intervals with morbidity. Primigravida seem to have higher odds of bleeding, rupture and edema, but the effects are too small to be significant. They do have significant higher odds of hypertension.

The type of previous pregnancy and delivery is related to morbidity in the next pregnancy. Women with a previous premature/abortion or birth by caesarian section show significant higher odds ratios for gestational hypertension (3.164), for TTB (1.303), and for

PROM (1.394) relatively to those with a previous normal delivery.

The type of health insurance used by the mother and her place of residence were used as proxies of her socioeconomic status. In this context, women enrolled in mutual health insurance have a significantly higher odds ratio for gestational hypertension (1.894) and a higher, yet not significant odds ratio for LLE (1.559) relatively to women with private insurance. Compared to women from Kigali city, those referred by health care centers located in the peri-urban and rural areas of Gasabo district have significantly higher odds ratios for gestational hypertension (2.482), for TTB (1.610) and for PROM (1.703). A significant increase in odds of TTB (1.746), in the odds of PROM (1.614) is also observed to women whose referring health care center was not mentioned on the hospital's obstetrical files.

Discussion and Conclusion

Results of the referral analysis indicate that primigravida, those with a short IPI (<=12 months) and a long IPI (>=60 months) have higher odds of being referred to district hospitals in Rwanda because of pregnancy and delivery complications. These results corroborate findings of previous studies[27-29] which indicated that short IPIs are correlated with adverse obstetrical and perinatal outcomes, while long IPIs are associated with increased risk of pre-eclampsia and TTB[13,30]. After excluding primigravida and considering the type of previous delivery, it is clear that adverse previous delivery outcomes (pregnancy loss, premature birth or neonatal death) lead to increased odds of being referred to a district hospital. Yet this does not imply that short and long intervals are always related to maternal morbidity.

The analyses of the Kibagabaga district hospital data do not show a consistent relationship between IPI length and all maternal morbidities. Short intervals (<12months) are not associated with TTB, PROM or LLE, but might be related to hypertension. This might seems surprising given the fact that the odds of referral are 1.5 times the odds of those with a healthy interval. This outcome could mean two things. The first is that (very) short intervals are related to the health status of the child but not to the health of the mother. The second is that local health centers, aware of the risks of pregnancy complications after a short interval, also refer mothers whose health status is not at stake.

The evidence for the effects of long intervals is far more convincing. The high odds of TTB and PROM support the physiological regression hypothesis[13]. These findings correspond to those who posited that the effect of long inter-pregnancy intervals is due to the fact that the protective effect that women might have acquired along the previous pregnancy is lost after a long interval[8,12,31].

The evidence is less strong for primigravida who show a significant increase in gestational hypertension, but less strong and non-significant effects for TTB and PROM. Again this might be obscured by the higher odds of referral for the primigravida. The primigravida status is known to be critical in terms of obstetrical performance; women who conceive for the first time will receive more antenatal, natal and post natal care to help them reach a good start of their reproductive health life[31] and might therefore be referred more often regardless of their health status.

The lower odds of being referred and the equal odds of maternal morbidity among older women (age=>35) in Rwanda provide further support for the physiological regression hypotheses[32]. Unlike the situation in developed countries, older women in Rwanda are mostly experienced mothers who have had several pregnancies before they conceive at higher age. Many of them enjoy the protective effects of the previous pregnancy. That could be the reason why the effect of long intervals did show up in the analyses, while the effect of higher age did not.

As socioeconomic proxy indicators, this study considered the wealth quintile and the place of residence (Kigali city vs other Regions) for the first analysis on delivery referrals. The type of insurance and the location of the health centers (Kigali City vs peri-urban or rural areas) were used for the second model on maternal morbidity. In the first analysis, women in the middle and poor wealth quintiles were referred less than more wealthy women. The same is observed for women not living in Kigali, they were also referred less. In the second analysis, women on mutual health insurance had significantly higher odds of gestational hypertension and (not significantly) higher odds of lower limb edema. Women from the peri-urban and rural area of the Gasabo district had higher odds of gestational hypertension, of TTB, and of PROM. This obviously means that wealthy women, living in urban areas have more chances of being referred to or to utilize higher level health care institutions relatively to poor women on mutual health insurance who reside far away in the peripheral areas of Kigali. The results correspond to the findings of Chambers and Booth[33] who identified three reasons for these lower referral rates. The first is linked to poverty, making women and their families slow in seeking medical assistance because of difficulties to pay transport and referral costs. The second is transfer delays, caused by either a late decision of the medical staff or the lack of ambulances to facilitate an immediate emergency obstetrical intervention. The third delay is caused by the shortcomings in the quality of care, inadequately trained and poor staff motivation at the level of the health care center. Despite the improvements in health care in Rwanda, access to high quality reproductive health care for the poor is still problematic.

To conclude, we did not find clear evidence that avoiding short birth intervals will help to reduce maternal morbidity, but we did find a strong effect of long intervals and of the adverse outcomes of previous pregnancies on this morbidity. However using hospital data to assess the role of the reproductive history has some clear limitations. Even in Rwanda the referral process is highly selective which may bias the results. More formal models, like the Heckman model that can simultaneously estimate the probability of referral and the probability of morbidity once admitted could control this selection bias, but would require data that link patients of local health centers directly to the hospital to which they are (not) referred.

Contribution of Authors

This research article is produced in the context of a PhD research, which implies combined efforts of Ignace Habimana-Kabano (the student), Dr. Annelet Broekhuis (the co-promotor) and Prof Pieter Hooimeijer(Promotor). Therefore, Mr. Habimana-Kabano conceived, designated the study, Dr. Annelet Broekhuis provided the writing and editing support while Prof Pieter Hooimeijer contributed with general technical support along the analysis process including the models construction and paper editing to its final stage.

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