Accumulated reproductive life histories and grip strength in Indonesia: a life course latent class analysis approach

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Abstract

There is a growing need to understand the impact of the cumulative burden of reproductive lives on women's health later in life in the global South where populations are ageing fast while maternal mortality and morbidity are still high and the level of resources chronically low for decades. We don't know how adverse reproductive events such as unplanned high fertility, unsafe abortions, stillbirths and terminations might affect physical functioning and muscle strength later in life.

Grip strength has been widely recognised as a suitable objective measure of health deterioration but so far there are only few studies in low-resource countries and none linked to reproductive histories. Using a three-step latent class modelling to analyse the Indonesian Family Life Survey (IFLS) the aim of this study is to understand the impact of cumulative reproductive histories on ageing, through grip strength later in life. Results show a two-class classification with women in one class showing the positive impact of low parity on grip strengths, the negative impact of child death in the other class and in both classes the negative impact of stillbirths. Early childbearing (before age 18) and pre-menopause also show a negative impact on grip strength.

This study demonstrates the need to undertake research in this field and it is set within the greater need to understand how high fertility might affect the ageing process of women in a low-income setting. This is crucial for health systems readiness and to pave the way to appropriate health and social care reforms.

Introduction

The attention on women's health in Low- and Middle-Income Countries (LMICs) in the last three decades has been prominently focused on reproductive health and mainly around the reproductive period. Women are largely seen as reproductive objects and the narrative around women's health has been heavily dominated by maternal health studies (Raymond, Greenberg et al. 2005). After decades of high fertility, poor maternal health outcomes and unsafe abortions in low resource contexts, we do not have a clear picture of post reproductive years, of what impact this might have on the ageing process and more generally on later life health. Generally, existing research focuses on single outcomes of reproductive lives (e.g.: parity or age at first birth) to connect the impact of fertility histories to later health. We miss, both in low and high-income countries, a holistic analysis of the life course reproductive experiences and how these might affect health in older ages (Mishra, Cooper et al. 2010).

In High Income Countries (HICs) the relationship between fertility histories and later life health has been studied somewhat in depth and previous research has shown that nulliparous, high parity or women who started childbearing early have a higher risk of mortality or poorer health (Grundy and Read 2015, Read and Grundy 2016). However, with rare exceptions, these studies are mainly limited to high income settings often come up with non-significant results, in addition to being limited in terms of the outcomes used (e.g.: it mainly focuses on live births) and in the understanding of the mechanisms that drive this relationship (Gustafsson, Janlert et al. 2011, Premji 2014).

Scanty evidence from low-income countries is also inconclusive with age at first birth being the most significant factor. For example, a study conducted in Senegal showed the impact of age at first and last birth as well as number children and their sex on the woman's mortality (Duthé, Pison et al. 2016). The study showed above all the protective effect of having a boy in certain rural areas. In addition, evidence in Brazil showed that early childbearing can accelerate the process of ageing measured through grip strength and gait speed (Câmara, Pirkle et al. 2015). Perhaps the study that looked more broadly at reproductive histories to include parity, age at first birth as well as terminations is one conducted on Indonesian data which include allostatic load (a measure of wear and tear of the body) as the main health outcome. It showed the negative impact of terminations and early childbearing on women's allostatic load at older ages but didn't detect any effect of parity (Leone, Väisänen et al. 2023). However, the study had a relatively small sample (n=2001) and due to the sample's age restrictions, it did not include a wider range of reproductive health related variables such as pregnancy complications and stillbirths.

Furthermore, among studies on life course adverse events impact later in life, the focus is generally on mortality and less so on intermediate outcomes such as physical functioning. Grip strength for example, is often used as a proxy of health deterioration and ageing but thus far the evidence is inconclusive on how it is impacted by negative reproductive events across the life course (Duchowny and Clarke 2018).

Detecting early signs of ageing whether physical or cognitive can be cost saving as it would lead to early intervention and a more effective active ageing later in life. As life expectancy increases globally, we need to understand how contextual settings can make the difference in the ageing process from mid-life. This is particularly true in low-income countries where our knowledge on the ageing process is rather scarce and where more than

everywhere else the costs of ageing will hit economies the worse as the social care systems are often inexistent.

Using the Indonesian Family Longitudinal Survey (IFLS), the aim of this study is to understand the cumulative effect of reproductive histories on women's grip strength later in life. We aim to test the following hypothesis: women with a higher burden of adverse reproductive health related events are more likely to have a lower grip strength later in life.

Conceptual framework: the cumulative approach

We ground our study within the accumulation of risk in the life course (Ben-Shlomo and Kuh 2002, Elder, Johnson et al. 2003) and the cumulative inequality theories (Geronimus, Hicken et al. 2006) to develop a model which looks at life course reproductive health histories impact on health (Mishra, Cooper et al. 2010). The accumulation of risk is looked through the lens of risk clustering models. The clustering approach assumes that there are groupings of individuals that would face adversities in similar manners. This is usually the case for different socio-economic groups that for example would have similar access to health services while giving birth or would experience similar environmental adversities during childhood which would affect health later in life (Ben-Shlomo and Kuh 2002). Clustering could also occur due to cohort effects of policy changes or to health risk behaviours (Liao, Mawditt et al. 2019). We can also assume that women with specific sets of adverse reproductive events (e.g.: emergency c-section, bleeding at birth, stillbirths) are clustered within same adverse characteristics.

Within the cumulative clustering lies the *weathering hypothesis* (Geronimus, Hicken et al. 2006) and the *cumulative inequality theory* are used to add a further dimension, contending that cumulative inequality interacts with one's ability to mobilise social, economic and psychological resources, shaping the individual's health and wellbeing in old age (Ferraro and Shippee 2009). Individuals with early life traumas are thus more likely to encounter and generate further stressful events (e.g.: the loss of a child or major health issues in childhood) throughout the later life stages, but with fewer personal and psycho-social resources to cope with them. Moreover, such individuals are more likely to amplify their biological and emotional response to any later-emerged stressor and are predisposed to self-medicating behaviours like smoking, drug use and consumption of high-fat diets (Nusslock and Miller 2016).

The weathering hypothesis, which states that the health of individuals who have been exposed to socio-economic disadvantage throughout their life, deteriorates more quickly than those in more advantageous positions (Geronimus, Hicken et al. 2006). Several studies provide support for the accumulation of risk hypothesis in that cumulative measures of SES adversity across childhood and adulthood are stronger predictors of physiological risk, such as high inflammatory burden (e.g., Loucks et al., 2010 ; Pollitt et al., 2008) and weight gain (e.g., Baltrus et al., 2005 ; Senese et al., 2009), than measures from single points in the life course (Gruenewald, Karlamangla et al. 2012). It is feasible to hypothesise that women in low income settings, in particular from low income groups, might have experienced a greater burden and higher level of stressors than women from high income settings. In this study we want to apply those theories to the impact of reproductive lives on women's health through grip strength.

We designed a model which sees the link between cumulative adverse events (insults) in childhood, adulthood and in particular which looks at reproductive histories controlling for behavioural and socio-economic determinants.

Falkingham et al (2020) highlighted the need to look at the cumulative effect through the synthesis of overall previous experiences (Falkingham, Evandrou et al. 2020). In this study we start from a single-issue approach through multivariate fixed effects models moving to a cumulative one through latent class analysis where we account for childhood as well as reproductive histories events. We consider pregnancy complications and possible traumas (e.g.: stillbirth, c-section, hypertension) as well as pregnancy outcomes and their timings and possible stressors which could have had an impact on women's health later in life.

Grip strength and fertility histories

Grip strength is widely regarded to be an excellent predictor of disability and ageing. When standardised it produces what is now recognised to be a reliable objective measure of the health status (Rantanen, Guralnik et al. 1999, Sayer, Syddall et al. 2006, Taekema, Gussekloo et al. 2009). Grip strength associated with worse health later in life and worse quality of life in several studies (Sayer, Syddall et al. 2006). So far, the evidence on the determinants of grip strength in LIMCs is rather limited mainly due to lack of data.

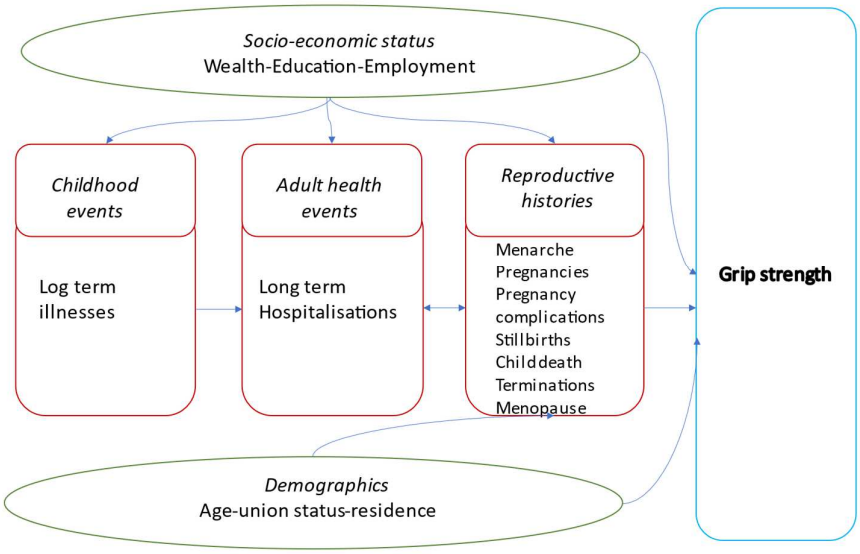
Two studies have shown that grip strength declines from the same age for both men and women at around age 40 but men loose strength at a faster pace relative to their peak (Metter, Conwit et al. 1997, Nahhas, Choh et al. 2010). It is unclear though whether women's higher burden of disease compared to men could be linked to their reproductive lives.

Grip strength declines at different paces depending on the timing of the last period. The transition through menopause does have a significant impact on grip strength which is generally negatively correlated with menopause with pre-menopausal women reporting a lower level than post-menopausal (Cooper, Mishra et al. 2008, Câmara, Pirkle et al. 2015).

Reproductive health and the life course:

Starting from menarche (the age at first birth) women go through a series of reproductive events. Early menarche (before age 13), early childbearing (before age 18), terminations to include miscarriages, stillbirths and induced abortions, pregnancy complications and early/premature menopause (before age 45) are all known to provide a lasting impact on women's health as well as often being the cause of an underlying condition or trauma (Deecher, Andree et al. 2008, Mishra, Cooper et al. 2009, Mishra, Cooper et al. 2010, Anagnostis, Theocharis et al. 2020).

Figure 1 Conceptual framework



The context

Indonesia is a lower middle-income country which has experienced a considerable economic growth as well as a considerable fertility decline over the last three decades Life expectancy was 48 years in 1960 while it has risen to 69 years in 2014. Births attended by skilled staff ≈40% in early 1990s with an increase to 87% in 2013. Finally, contraceptive prevalence was <30% in the mid-1970s, 63% in 2013 (UNPD 2017).

We are therefore looking at a country which only recently had a very high level of fertility and more in general a need of safe maternal health care which often would go unmet.

Data and analytical strategy

Study sample

This study uses the fifth wave (2014) of the Indonesian Family Longitudinal Survey (IFLS) in addition to information reconstructed from the first four waves (1996-2007). Wave 5 included 16,024 households with 58,337 individuals (Strauss, Witoelar et al. 2016). Of these A total sample of 13021 women over the age of 15 who had their grip strength measured was initially selected. IFLS has a low attrition rate (92% of wave 1 recontacted in wave 5) and it is generally considered to be of very good quality. Full reproductive histories were only collected for women aged 15 to 49 over the waves and for this reason some of the variables we included might have a restricted sample aged 15 to 60 (those aged 49 in 1993 the first wave). For this reason, we were only able to select a limited number of reproductive history variables for the overall model. We model the key outcome separately according to different reproductive variables to maximise the size of the samples analysed and the number of outputs used.

Accumulated reproductive life histories

We used 4 variables to calculate the LCA membership of individuals in the sample. Parity (0,1,2,3,4 and 5+), number of terminations (0,1, 2+), child death and stillbirths (0, 1-2,

3+). In the analysis we also tested the inclusion of a set of other reproductive histories variables to include: pregnancy complications in at least one pregnancy (haemorrhage, high blood pressure, eclampsia, high fever), age at first birth (before age 20, between 20 and 24 and over 24), early (before age 13) menarche and early menopause (before age 45) as binary variables.

Health outcome

Grip strength is the mean of the best result obtained in each hand squeezing a Smedley's hand dynamometer where the dominant hand is reported by the interviewer. It is widely regarded as an excellent predictor of disability and worse health at older ages (Sayer, Syddall et al. 2006). When standardised it produces a reliable objective measure of health status (Rantanen et al., 1999, Sayer et al., 2006, Taekema et al., 2009). We first apply a linear regression fixed effects model to identify the relationship between key lifecourse events in reproductive life and grip strength. We then apply latent class analysis (LCA) to add up the cumulative effects of key lifecourse events related childhood and reproductive lives which include: parity, terminations (whether induced or natural), childhood illnesses, hospitalisations, child deaths, pregnancy complications, c-sections, age at first birth. This will be done iteratively.

Control variables

In the control variables we use socio economic factors known to have an impact on health later in life (Yount 2008, Merkin, Karlamangla et al. 2014, WHO 2016). These include residence (rural or urban), education achievement, type of employment (heavy physical, sedentary, housework and unemployed), wealth index as a proxy for income calculated using the Principle Component Analysis of the assets (e.g.: ownerships of household items, type of floor/roof) in line with previous literature (Filmer and Pritchett 2001).

We also control for risk factors such as smoking behaviour (ever smoked). We could not control for drinking (the question was not asked most likely because of the majority of the population being muslim) and physical activity. The full distribution of the variables included is reported in table 1. The missingness values depend on the sample selection for the questions included in the survey (e.g.: complications only asked to women aged 15-49 across the 5 waves). The samples are representative of the overall sample of the population within the characteristics of the selection (e.g.: age group).

Table 1 Outcomes distribution. IFLS 2014 sample

	Sample size	Mean	Correlation with grip strength	% Missingness
Grip strength	13021	26.68		27.82
Rep histories				
Parity*	8874	2.78	-0.02**	31.85
Terminations*	8874	0.07	-0.07*	31.85
Stillbirth*	8874	0.52	-0.23***	31.85
Complications*	6597	0.52	*0.01	42.7
Child death*	9033	0.10	-0.14***	30.63
Age at first birth*	6535	27.42	-0.10***	50.18
Demographics				

Age	13021	38.59	-0.16***	0
Marital status	13021	1.98	-0.05***	0
Ethnicity	13021	3.53	-0.04***	0
Residence	13021	0.41	0.01	0
Socio-economic				
Education	12404	3.25	0.08***	4.74
Wealth	12093	3.25	0.10***	0.22
Employment	12568	2.27	-0.08***	3.48
Health variables				
Smoking*	13021	0.37	0.07***	0
Hospitalisation in last 12 months*	13021	0.04	0.01	0
Childhood illnesses*	12919	2.69	-0.01	0.78

*denotes variables which were reconstructed using all 5 waves where data were missing

Methods

Latent class Analysis (LCA) is generally used to identify common groups of women that have experienced similar life-course reproductive health related experiences (Vermunt 2010). The LCA produces grouping through probabilistic models which are then utilised for the final modelling. Given the limitations in the data and the lack of full knowledge of women's characteristics we use this approach to account for commonalities in reproductive experiences.

For this study, we use a three steps latent class analysis (Huang 2017). A one step approach would likely be unstable as any changes in the models (e.g.: adding or removing a variable) would mean reclassifying the cluster membership. In addition, using a simple regression model with LCA could potentially be biased due to a possible miss-placement of individuals by class. The three steps approach allows to assign individuals to a class group and to calculate the probability of misclassification (Vermunt 2010). We use a three steps bias corrected latent class approach based on the work by Tompsett and Stavola (Tompsett and De Stavola 2022). With this approach we use RStudio V 4.2.3 for steps 1 and 2 to include the use of the PolCA package and STATA V17 for step 3. Stata is used for step 3 as R would not be able to implement a Maximum Likelihood model which is easily implementable through structural equation modelling as easily as a one step LCA (Vermunt 2010). While R could be easily be implemented for steps 1 and 2 which are easier than in STATA. The two software have been shown to complement each other well (Tompsett and De Stavola 2022).

In step 1 we tested the number of latent classes starting with 2. The choice of the optimal number of classes was based on the comparison of various models using Akaike information criterion (AIC), Schwarz's Bayesian information criterion (BIC) and the sample-size-adjusted BIC (A-BIC), where a smaller AIC, BIC or A-BIC value indicates a better-fitted model.

The lifecourse adversities/events included for step 1 were: number of terminations (miscarriages and induced abortions), number of stillbirths, parity, and death of a child across the overall lifetime. We also considered intrapartum complications such as high blood

pressure, bleeding or extreme back pain. Due to the quality of the information and high level of missingness we decided to exclude it from the first step analysis.
In step 2 we used R to calculate the weights for each class to be used in step 3. The weights were the averages for each class in relation to the distal outcome and misclassification matrix for each class.
The third step estimated the SEM where the latent class variable was measured with STATA, and the measurement error was fixed and prespecified to the values obtained from step 2.

Results

Step 1

The cluster exercise showed Cluster 1 is the cluster of higher parity, higher risk of stillbirths and miscarriages as well as child death while cluster two has a more even level of parity and distributed around women with no major (Figure 2). While cluster 2 has a higher proportion at lower parities and of women with a higher number of stillbirths. The distribution of probability attribution of categories by class is reported in table 2.

Figure 2 Accumulated lifecourse reproductive histories adversities

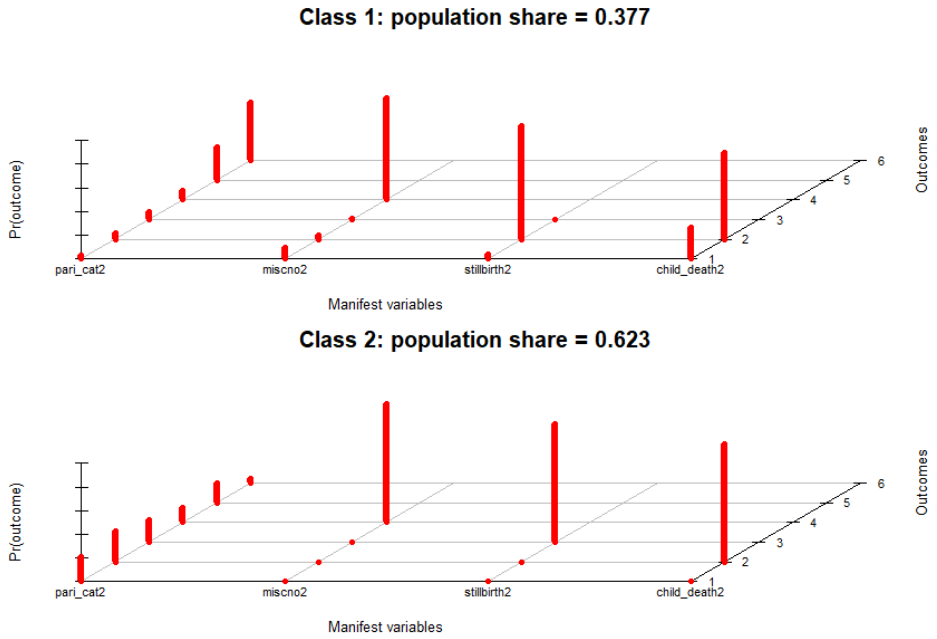


Table 2 distribution of probablity attribution of categories by class for reproductive histories

	Categories					
Parity	**0**	**1**	**2**	**3**	**4**	**5+**
class 1:	0.0339	0.0493	0.0676	0.0738	0.2846	0.4908
class 2:	0.2127	0.2615	0.1936	0.1270	0.1645	0.0407
# of terminations	**0**	**1-2**	**3+**			
class 1:	0.8613	0.0948	0.0440			
class 2:	0.9999	0.0000	0.0001			
# stillbirths						
	0	**1-2**	**3+**			
class 1:	0.0382	0.9616	0.0003			
class 2:	0.0002	0.0035	0.9962			
Child deaths	**no**	**yes**				
class 1:	0.2657	0.7343				
class 2:	0.0001	0.9999				

Step 2 determining the class weightings

We then calculated the weights' matrix to use in the third step. The matrix tells us the probability of being misclassified (table 3). Overall, the probability of being classified in class 1 when classified in class 2 is close to 0 (0.0009). Whereas the probability of being in class 1 when the actual class is 2 is slightly higher but nonetheless low (0.042). This matrix is then used to correct the classification calculated in step 1 when doing the models in step 3.

Table 3 Misclassification matrix

	Classification class	
Actual class	1	2
1	0.999	0.0009
2	0.042	0.958

Step 3 structural equation modelling with latent variables.

For the purpose of this first draft we present the full model without the extra reproductive variables to include pregnancy complications, premature menopause and age at first birth (we will discuss briefly the results of this latter variable though).

The model with the full sample shows no impact for terminations, a positive effect of parity 1 in class 1 and a negative effect of stillbirths both for 1 or 2 in class 2. Child death has a negative effect in class 2 only. Age shows a negative trend as expected. Being in a union has a positive effect in both classes while being separated/divorced is only positive in class 2. As

we don't know when they divorced we could expect an overall positive impact of being in a union in general over being alone in line with previous literature. Hospitalisations and childhood illness have no effect while smoking has a positive effect. This might be due to a selection effect that needs to be explored further. Education shows a positive gradient in particular for class two. The same is true in both classes for wealth. Rural areas show a positive effect in line with previous studies (Leone, Väisänen et al. 2023).
We don't report here the models that tested the other variables such as age at first birth, premature menopause (before age 40), early menarche (before age 13), pregnancy complications. The two variables which were significant were age at first birth where early childbearing (before age 18) and premature menopause had a negative effect on grip strength. The models showed a significant negative impact of terminations in the model that included age at first birth.

Table 4 Grip strength Latent class structural equation modelling results for full sample and for sample to include age at first birth.

	Class 1		**Class 2**	
	Coef.	Std. Err.	Coeff	STD error
LC W	1.72***	0.01	1.56***	0.01
Terminations (ref 0)				
1	-0.26	1.19	-0.16	0.50
2+	0.91	1.85	0.56	0.79
Parity (ref 0)				
1	1.43**	0.84	-0.17	0.40
2	0.05	0.76	-0.27	0.38
3	0.76	0.81	-0.20	0.37
4	-0.10	0.85	-0.35	0.38
5+	0.78	0.78	-0.21	0.33
Stillbirths (none ref)				
1	0.24	2.10	-2.34***	0.78
2+	-0.16	0.75	-0.78*	0.31
Experienced child death (ref no)				
yes	0.98	0.85	-0.58*	0.33
Age	-0.06***	0.02	-0.06***	0.01
Marital status (ref not in union)				
in union	3.83***	0.72	2.06***	0.30
Divorced/separated	3.23***	1.09	0.12	0.40
Childhood illness (ref no)				
Yes	-0.64	0.45	0.37	0.26
Hospitalisations (ref no)				
Yes	0.50	0.80	-0.45	0.46
Smoking (ref no)				
Yes	0.66*	0.36	0.71**	0.20
Ethnicity (Ref Javanese)				

Sundanese	-1.67***	0.58	-0.68*	0.31
Batak	-1.27	1.79	1.64	1.51
Minangkabau	-0.32	1.32	-1.64**	0.56
Balinese	-0.39	0.82	0.93	0.51
other	-0.13	0.38	-0.53	0.20
Education (Elementary ref)				
Junior high	0.98**	0.50	0.86**	0.25
High school	0.53	0.43	1.17***	0.22
University	-0.22	0.68	1.61***	0.32
Wealth quantile (ref poorest)				
Poor	1.33**	0.58	0.65*	0.28
Average	1.65**	0.61	0.91**	0.28
Rich	2.21***	0.58	1.25***	0.29
Richest	2.59***	0.64	1.08***	0.30
Residence (ref urban)				
Rural	1.07***	0.38	0.34*	0.20
Constant	35.24***	1.16	22.83***	0.52
Var e.W	0.23***	0.00	0.23***	0.00
Var e.grip	33.81***	0.90	33.81***	0.90

Discussion and conclusions

This is the first study to look at grip strength and cumulative reproductive histories in a LMIC setting. The results show a clear clustering around levels of ageing with parity, termination, child death and stillbirths as the key reproductive health variables setting the groups.

Beyond the possible selection effect (e.g.: being prone to the risk of stillbirths could potentially show a health issue), the results show a positive effect of low parity and negative of child death and stillbirth. This could potentially be linked to a debilitating mental health impact of those events as well as on the strain on the body mainly in a low resource setting. Early childbearing remains a negative factor as in previous studies. This paper also identifies pre-menopause as key risk factor which has been neglected in the past.

We plan to finalise the models and further understand the impact of other reproductive events in our future analysis.

Disentangling different events throughout the lifecourse will be key in understanding the of the ageing process. This study is very timely within the quest for a wider focus on ageing in LMICs and the shifting of priorities from communicable to non-communicable diseases where countries are the least prepared.

Future research will need to conduct similar analysis across settings. The cultural component of the coping mechanisms as well as the cohort effects need to be compared across time and space.

Unfortunately, the Indonesian data is very unique in its nature. It includes data across a wide range of ages (i.e.: 18 to 101) and it includes both measures of reproductive health as well as ageing. Most data either stop at 49 (e.g.: DHS) or start from 50 (e.g.: SAGE) with the latter not including measure of reproductive histories. A true lifecourse approach can therefore not be applied until a concerted effort in data collection is made to understand the overall impact of reproductive histories across time and place.

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