Trends in Kin Networks and Self-rated Health of India's Older Population, 1995–1996 to 2014

Judith Lieber, London School of Hygiene & Tropical Medicine

Lynda Clarke, London School of Hygiene & Tropical Medicine

Sanjay Kinra, London School of Hygiene & Tropical Medicine

Introduction

India's older population (aged 60 and above) is growing rapidly and is expected to triple to 300 million by 2050 (Dey, 2016). The sociodemographic forces that are ageing India's population are influencing family structures, which will in turn have implications for support, and consequently health, of the older population (Berkman *et al.*, 2000). Children and spouses provide the vast majority of support for older dependent Indians, for instance through co-residence, financing healthcare expenses, and caregiving day-to-day (BKPAI, 2011; HelpAge, 2014). Support from other sources is limited. Only one-fifth of the population work in the formal sector and are thus eligible for private pensions (International Labour Office, 2018), whilst public pensions are nominal, difficult to obtain, and aimed at vulnerable groups such as widows (Rajan and Mishra, 2011; Dey, 2016). Formal care is available only to the urban middle-classes, 75% of older people live rurally (Jeyalakshmi, Chakrabarti and Gupta, 2011), and care homes are highly stigmatised (Brijnath, 2012). Finally, dependency, both economic and health-related, is high. Over one-third of the older population are below the poverty-line, three-quarters are economically dependent on others (BKPAI, 2011), half have been diagnosed with a chronic disease (Basu and King, 2013), and almost 40% have some form of disability (ICED, 2014).

Fertility has more than halved since the 1970s (Registrar General & Census Commissioner of India, 2012), thus reducing the numbers of children available to support. It is unclear if older Indians are more or less likely to have a spouse with time. The probability of being widowed is related to gender specific differences in mortality and ages at marriage, trends of which are moving in opposing directions (Registrar General and Census Commissioner, 2010; Das and Das, 2013).

To understand how sociodemographic trends will influence health of India's older population, we describe changes in the structure of close kin (namely numbers of sons, daughters, spouse) over the past two decades, and establish which kin are associated with self-rated health. Kin also influence health through a range of other biosocial mechanisms that vary by social context, whilst children act directly and physiologically on women's health. India is a largely patriarchal, patrilocal, and patrilineal society, which results in highly gendered kin roles, and the current older population experienced high fertility (Registrar General & Census Commissioner of India, 2012). Thus, we expect the relationships and underlying mechanisms to vary between mothers and fathers, and sons and daughters. To elucidate potential mechanisms, biosocial versus physiological, we assess the relationship between kin and health by gender.

Background

Biosocial pathway

Kin influence older people's health outcomes, for example, mortality is higher in childless individuals (Högnäs *et al.*, 2016) and the married tend to have better health than the unmarried (Manzoli *et al.*, 2007). Various biosocial mechanisms have been proposed, for instance, kin can influence health-related behaviours such as diet (Berkman *et al.*, 2000; Högnäs *et al.*, 2016), increase role-conflict (Wikman *et al.*, 2009), and influence social-psychological outcomes such as self-esteem or stress (Holt-Lunstad, Birmingham and Jones, 2008; Holt-Lunstad, Smith and Layton, 2010). Finally, kin are key recipients and sources of financial, instrumental, and emotional support across the life-course, which is particularly important at later ages due to declines in health.

India's social structure means sons and daughters influence their parents' health differentially. Across the life course, sons are more likely to co-reside with their parents and thus contribute economically to the household, whilst daughters are expected to move to her husband's household on marriage. Sons also contribute economically through the receipt of dowry, whilst the opposite is true for daughters. Dowry costs can be high, to illustrate 15% of all household loans in 2004-05 were to

fund dowry (Desai, 2005). At older ages, filial norms dictate that sons co-reside with their parents and provide financially, whilst their wives are expected to act as caregivers. Support from daughters on the other hand is limited, as her filial responsibilities lie with her in-laws. Two-thirds of economically dependent older Indian's rely on their sons for economic support, versus 4% on daughters (BKPAI, 2011), and whilst 85% of Indians expect to live with their sons at older ages, only 24% would consider living with a daughter if their son was unavailable (Desai, 2005). The socially prescribed roles of sons and daughters have in turn led to a preference for sons, whilst daughters can be perceived as a burden (Vlassoff, 1990; Diamond Smith, Luke and McGarvey, 2008; Dubuc and Sivia, 2018).

Men are traditionally expected to provide economically for the family, whilst women are expected to do domestic and caring tasks. Consequently, the exchange of support between spouses in India differs qualitatively. Women play a key role in caring for dependent husbands. In a multi-site dementia study, wives were the primary caregivers for 29% of persons with dementia, whilst husbands were caregivers for 11% (Prince *et al.*, 2004). There is evidence that recent widowers are at increased risk of diabetes, which may be a result of worsening diet due to loss of a wife's cooking (Perkins *et al.*, 2016). On the other hand, as a result of patrilocality and gender norms, women tend to be economically and socially dependent on their husbands (Dyson and Moore, 1983). Women are less likely to own assets (BKPAI, 2011) and inheritance is a key motive to support from children (Silverstein, Parrott and Bengtson, 1995; Patel and Prince, 2001) Thus widowhood can result in declines in social status, discrimination, and limitations on access to economic resources for women (Chen and Dreze, 1992; Agarwal, 1998).

Physiological pathway

Fertility trends will also have direct implications for the health of women in India, due to the physiological effects of pregnancy, childbirth, and lactation. Large hormonal fluctuations are proposed to reduce the incidence of several related cancers, for instance breast cancer rates are higher in childless women (Ewertz *et al.*, 1990). On the other hand, there is some evidence that high parity is associated with higher risk of diabetes and cardiovascular disease (Nicholson *et al.*, 2006; FowlerBrown *et al.*, 2010; Lv *et al.*, 2015). Evolutionary theory purports a trade-off

between fertility and women's physical condition, as their energy is channelled into reproduction rather than somatic maintenance. In addition to high parity, other components of fertility such as early first births and short births intervals are also associated with poor health at older ages (Doblhammer and Oeppen, 2003; Grundy and Tomassini, 2005; Barclay *et al.*, 2016). There is a theory that bearing a male child is more physiologically taxing for a mother, as evidenced by faster intrauterine growth and higher energy expenditure (Marsal *et al.*, 1996; de Zegher, Devlieger and Eeckels, 1999; Tamimi *et al.*, 2003).

The Indian population under study were born in the first half of the 20th century and experienced their fertility during the early stages of the demographic transition. Although fertility was declining, high parity births (e.g. 5-plus), short birth intervals, and early first births would have been common, potentially leading to a particularly high physiological burden.

Selection effects

Health selection effects are important when assessing the relationship between kin and health. The "healthy pregnant woman effect" refers to the association between fertility and women's health, whereby women in poor health are less able to have one or several children. For instance, there is evidence that mortality from non-maternal causes is lower in pregnant women (Ronmans *et al.*, 2001). This effect will be strongest in natural fertility populations (similar to the study population) where fertility is not being consciously restricted, i.e. with contraception, and thus differences in parity are linked to variations in health. There is also evidence that healthier people are selected into marriage, as they are more likely to marry, remain married, and remarry (Manzoli *et al.*, 2007). As marriage is universal in India, and remarriage is restricted for women, who are more likely to be widowed, this effect is less relevant for the study population.

Current evidence

There is currently no evidence as to how the structure of close kin, namely the number of sons, daughters, and spouse, of India's older population has changed over time. Two studies have assessed the relationship between children and older Indian's health, and reveal contrasting results. A 1980s survey demonstrated that

sons were associated with lower odds of mobility difficulties and daughters had no effect (Sengupta and Agree, 2000), whilst a 1990s survey demonstrated that having one or more daughters was associated with better self-rated health for fathers, with no effect in mother's or of son's (Sudha *et al.*, 2006). Evidence from a cohort in Bangladesh, a sociodemographically similar population, demonstrated declining mortality with rising numbers of surviving children for both men and women (Hurt *et al.*, 2004). Current evidence indicates that marriage is associated with positive health outcomes for older Indians, with varying effects by gender. Some studies reveal a larger benefit for women (Sudha *et al.*, 2006; Perkins *et al.*, 2016; Stewart Williams, Norström and Ng, 2017), whilst other demonstrate similar effects (Hirve *et al.*, 2012).

Thus, it remains unclear how sociodemographic trends will affect the health of India's older population, and as such, we have the following objectives:

Objectives

1. Describe trends in the structure of close kin (number of sons, daughters, spouse) for India's older population (aged 60 and above) (1995-96 to 2014)
2. Determine the relationship between kin and older people's health
3. Assess the relationship between kin and health by gender, to elucidate potential, biosocial or physiological, pathways

Hypotheses and predictions

If the relationship between children and parents' health is a result of biosocial mechanisms, the effect will differ by gender of the child, but not the parent. If the relationship between children and parents' health is a result of physiological mechanisms, the effect will differ by gender of the parent. As such, we make the following predictions for the relationships between children and health:

1. If children are the main source of support in later years, having few (zero or one) child(ren) will be associated with worse health for both men and women.
2. If the biosocial benefits of sons outweigh those of daughters, sons will be associated with better health for both men and women, whilst the effect of daughters will be smaller or negative.
3. If having and rearing many children is physiologically burdensome, having many (six or more) will be associated with worse health for women, but not men.

Method

We use individual level data from three cross-sectional (1995-96, 2004 and 2014) and nationally representative household surveys, collected by the Indian National Sample Survey Office (NSSO). The surveys collected data on social and health outcomes, in addition to sociodemographic data. Each included a module for persons aged 60 or above, which asked questions on family structure, economic dependence, and health. Age 60 is culturally perceived as old-age, for instance eligibility for pensions starts at 60 or 65 (Kumari Bhat and Dhruvarajan, 2002; Dey, 2016), and a recent study, using a measure that encompassed functional and cognitive health, estimated the old-age 'threshold' at 58, (Balachandran and James, 2019). Each survey used a stratified multi-stage design, sampling 33,991, 34,808 and 27,245 older individuals respectively, resulting in a total sample size of 96,044. This is the only data that allows the description of trends in the structure of older people's close kin and health, and the large sample size allows examination of relationships by gender.

The outcome is the respondent's own perception about their current state of health (self-rated health (SRH)), which is categorised as excellent/very good, good/fair, and poor (hereon referred to as excellent, good and poor). There is strong evidence that SRH is a reliable and holistic measure of health in India. For instance, SRH is associated with different components of health, including mental, physical, and functional health, and with more objective measures such as chronic disease diagnosis (Cullati *et al.*, 2018), whilst poor SRH is associated with increased mortality (Hirve *et al.*, 2012; Falk *et al.*, 2017).

The survey collected data on the number of sons and daughters alive at the time of the survey, which we categorised as 0, 1, 2, 3, and 4-plus, as we do not necessarily expect a linear relationship with health (Hurt, Ronsmans and Thomas, 2006; Högnäs *et al.*, 2016; Zeng *et al.*, 2016). As the question relates to number of children alive at the survey, these variables measure both the prevailing fertility and mortality conditions. The two were summed to total number of children alive, which was categorised as 0, 1, 2-3, 4-5, 6-7, and 8-plus, as guided by a meta-analysis which revealed a diverging association between men and women's longevity at parity 7 (Högnäs *et al.*, 2016). Finally, marital status was coded as being currently married

versus not. Divorce and never marrying are very rare, the two combined encompass <2% of the sample, therefore, individuals who are not currently married are mostly widowed. Not living with a spouse is also uncommon therefore being currently married corresponds to having and residing with a spouse.

To answer the first objective, we provide descriptive statistics, weighted for sampling strategy and age-standardised to the 1995-96 survey age distribution. We calculated predicted probabilities using the STATA margins command and tested the strength of evidence within each model (StataCorp, 2017). We present the descriptive statistics by gender for SRH and marital status due to large gender differences. To answer the second and third objectives, we use ordinal regression. Ordinal regression assumes that the relationship between each set of outcome categories is the same ("proportional odds"). We tested this assumption on the full model with the autofit option of the gologit2 command (Williams, 2016), which was set at a significance level of 0.01 to limit trivial assumption violations resulting from the large sample size. The assumption was not violated for any of the exposures and results of the unconstrained model were similar to the ordinal model, therefore we used ordinal regression.

We ran two separate models due to collinearity between the children measures, each controlling for the same sociodemographic variables: age (five-year intervals, 60-64 to 80 plus), gender, education (below primary, primary, middle to secondary, above secondary), socioeconomic status (quintiles), living arrangement (alone, with spouse only, with children and grandchildren, with children, with others), region (south, west, north, central, east/north-east), and survey year. We developed the socioeconomic status variable from household consumption data. We used a recommended adjustment to account for variations in household size and composition (Deaton, 2018), adjusting for inflation using the consumer price index of each survey year (World Bank, no date), and finally split the adjusted consumption data into quintiles separately by urban and rural residence. A higher quintile indicates higher socioeconomic status.

There was no evidence that the relationships between kin and health varied across the survey rounds (Wald test $p>0.100$) (table 3; appendix 1), therefore we compiled the three surveys for the final regression model. Conceptually, this

population corresponds to the Indian population aged 60 and above living between 1995-96 and 2014, therefore we adjusted the survey weights of the later surveys to account for the larger older populations in India at these time-points (Korn and Graubard, 1999; United Nations, 2013). Throughout, we used Wald tests to determine strength of evidence for interactions.

We used multiple imputation to account for missing data, which was greatest in the number of children variables, 14%, 11% and 7% missing in total children, daughters, and sons respectively. All other variables were <3% missing. Whilst the complete case sample was large (N=76,639), we assumed the surviving children data to be missing not at random – with zero sons or daughters being more likely to be missing – which could have biased the effect estimates. By including auxiliary variables (caste category, mobility, change in SRH, economic dependence, household size, year, urban residence, self-reported illness and hospitalisation in the past year) as well as the analysis model variables in the imputation model, we assumed a missing at random pattern. We used the chained equations method and imputed 10 datasets. Results from analysis of the complete case and the imputed data (N=96,044) are very similar and we selected to use the imputed data for the final analyses. All analyses were conducted using STATA 15, and we used the mi estimate and svy prefixes to account for the imputed data and sampling design throughout (StataCorp, 2017).

Results

Table 1: Background characteristics of the older Indian population (1995-96 - 2014)

	Women		**Men**		**Total**	
	%	**95% CI**	**%**	**95% CI**	**%**	**95% CI**
Age (years)						
60-64	36.0	35.1-37.0	34.2	33.3-35.2	35.1	34.5-35.8
65-69	29.2	28.3-30.0	29.2	28.3-30.1	29.2	28.6-29.8
70-74	18.4	17.6-19.2	19.3	18.6-20.1	18.9	18.3-19.4
75-79	7.8	7.3-8.3	8.8	8.2-9.4	8.3	7.9-8.7
80+	8.6	8.1-9.1	8.4	7.9-8.9	8.5	8.1-8.9

Female					50.5	50.0-51.0
Education						
Below primary	85.9	85.2-86.6	61.9	60.8-62.9	74.0	73.3-74.7
Primary	6.1	5.6-6.6	11.9	11.3-12.5	9.0	8.6-9.4
Middle to secondary	6.3	5.8-6.7	19.8	19.0-20.6	13.0	12.5-13.5
Above secondary	1.7	1.4-2.0	6.4	5.9-7.0	4.0	3.7-4.4
Socioeconomic status						
1	24.6	23.7-25.6	22.9	22.0-23.8	23.8	23.0-24.6
2	18.2	17.5-19.0	17.9	17.2-18.7	18.1	17.5-18.7
3	17.7	16.9-18.5	17.5	16.7-18.3	17.6	17.0-18.3
4	17.9	17.1-18.7	18.9	18.0-19.7	18.4	17.7-19.1
5	21.5	20.6-22.4	22.8	21.8-23.7	22.1	21.3-22.9
Living arrangement						
Alone	6.3	5.8-6.8	1.8	1.6-2.1	4.1	3.8-4.4
Spouse only	9.1	8.5-9.7	16.3	15.5-17.1	12.7	12.0-13.3
Children and grandchildren	63.5	62.5-64.5	53.4	52.4-54.4	58.5	57.7-59.4
Children	15.0	14.3-15.8	23.5	22.7-24.4	19.2	18.5-19.9
Others	6.1	5.7-6.6	4.9	4.5-5.3	5.5	5.1-5.9
Region						
South	27.8	26.6-28.9	25.7	24.6-26.8	26.8	25.8-27.8
West	15.7	14.8-16.5	14.7	13.8-15.5	15.2	14.4-16.0
Central	22.3	21.3-23.3	22.6	21.6-23.5	22.4	21.5-23.3
East/North east	21.2	20.2-22.2	24.4	23.3-25.5	22.7	21.8-23.7
North	13.1	12.3-13.9	12.6	11.9-13.4	12.9	12.2-13.6
Survey year						
1995-1996	23.2	22.2-24.1	23.1	22.2-24.1	23.2	22.3-24.0

2004	32.8	31.8-33.8		33.4	32.4-34.5	33.1	32.2-34.1
2014	44.0	42.7-45.3		43.4	42.2-44.7	43.7	42.6-44.9
CI; confidence interval							

Table 1 summarises the sociodemographic characteristics of the Indian population aged 60 and above between 1996 and 2014. The average age is 67.6, with little difference between men and women. Levels of education are low, men are more educated (38.1% have primary or above although in comparison to 14.1% of women). Living alone is rare but more common for women (6.3 versus 1.8% of men), whilst living with only a spouse is more common in men (16.3 versus 9.1% of women). The vast majority of older people live with their children (80%). More people live in the south versus the rest of the country, which is logical as population ageing has occurred more rapidly there. The prevalence of people in each socioeconomic group and survey year are a result of the variable coding and the adjustments of the survey weights.

Figure 1: Trends in self-rated health of older Indian women and men (1995-96 to 2014)

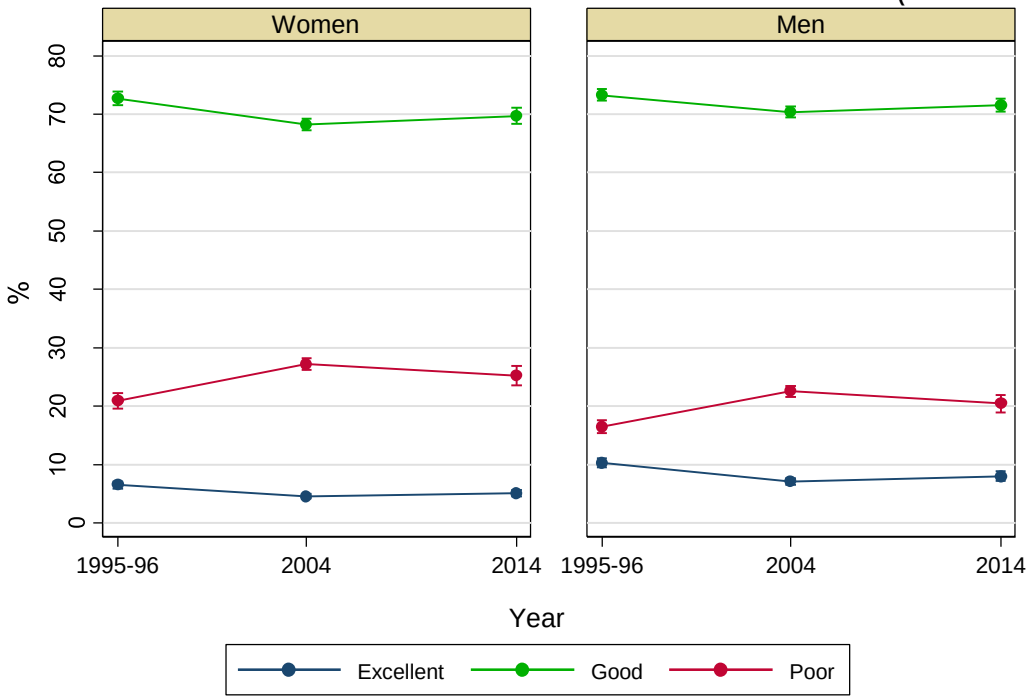

Figure 1 demonstrates that self-rated health of India's older population worsened between 1995-96 and 2004; prevalence of poor health rose by approximately 6%, whilst excellent health declined by 2-3% for women and men ($p<0.001$). In the second inter-survey period, health improved slightly, with poor health declining by 2% for women and men ($p=0.036$ and 0.014 respectively), and excellent health showing no further changes.

Figure *2: Trends in number of children of India's older population (1995-96 to 2014)*

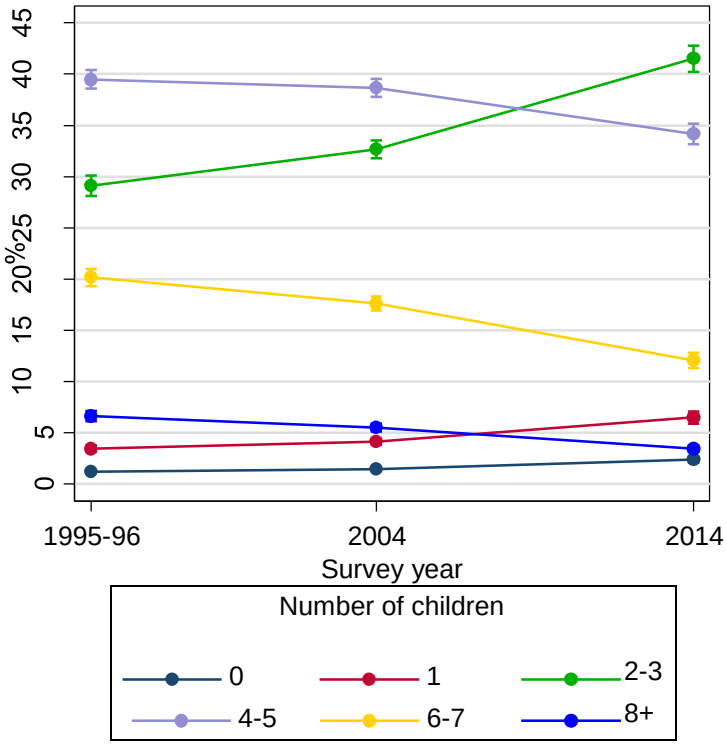

Figure 2 demonstrates that numbers of children have declined. By 2014, older Indians had on average 3.7 children in comparison to 4.5 in 1995-96 (not shown). Having four-plus children has declined, with a particular drop in large families (6-7 and 8-plus), whilst having none or one child remains low (<5% and <10% respectively); by 2014 the majority of India's older population have 2-3 children.

Figure *3: Trends in number of daughters and sons of India's older population (1995-96 to 2014)*

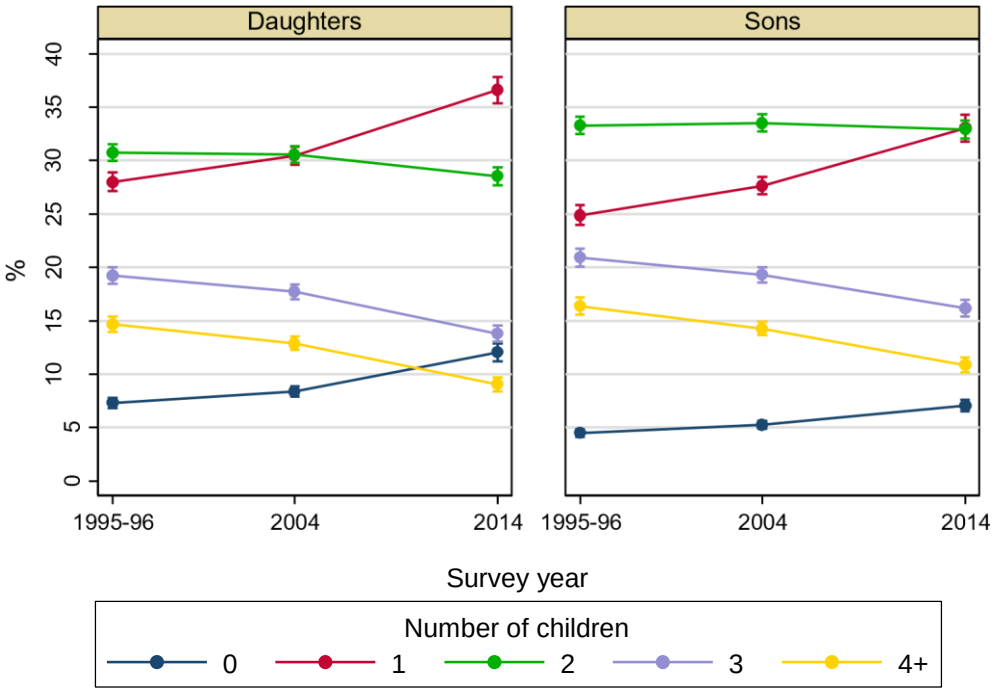

Figure 3 demonstrates that, by 2014, the majority of older individuals had 1 daughter in comparison to 2 in 1995-96. Having no daughters has risen by 75% since 1995-96; over one in ten older people do not have a daughter in 2014, similar or higher than numbers with 3 or 4-plus daughters. Having 1 or 2 sons is most common in 2014 due to the decline in having 3 or more, whilst having no sons has increased by 50% but remains rare (7% in 2014).

Finally, it is almost twice as common for older men to have a spouse, 83% in 2014 versus 43% of women, and being currently married has risen by 5% and 4% for women and men respectively ($p<0.001$) since 1995-96.

Table 2: Bivariate association between kin and poor self-rated health in India's older population (1995-96 - 2014)

		Total	
		%	**95% CI**
No. of children	**0**	23.9	19.6-28.2
	1	22.4	19.4-25.4
	2-3	20.6	19.4-21.7

	4-5	21.5	20.5-22.6
	6-7	24.5	22.9-26.0
	8+	27.1	24.2-29.9
No. of sons	**0**	23.9	21.2-26.5
	1	21.4	20.1-22.6
	2	21.4	20.2-22.5
	3	21.2	19.8-22.7
	4+	25.2	23.5-27.0
No. of daughters	**0**	21.1	19.1-23.2
	1	20.1	19.0-21.3
	2	22.7	21.5-23.9
	3	22.7	21.0-24.4
	4+	25.3	23.5-27.2
Marital status	**Unmarried**	27.7	26.6-28.7
	Currently married	18.3	17.5-19.2
CI; confidence interval			

For brevity, results from the bivariate analysis have been presented for poor SRH of the total population, as conclusions are similar to those for men and women (table 4; appendix) and excellent and good health. The associations reveal that poor SRH is lowest in individuals with 2-3 children and worsens with both declining and increasing numbers of children. Individuals with 8-plus children have the highest prevalence of poor SRH, 27.1% versus 20.6% with 2-3 children. Poor health is lowest with 1-3 sons, and higher with 4-plus or 0. Poor health is lowest with 1 daughter and increases with 0 and rising numbers of daughters. Finally, the lowest unadjusted prevalence of poor health is in married individuals, with a ten-point difference between the married and unmarried (18.3% versus 27.7%).

Table 3: Ordinal regression of worse self-rated health in India's older population, 1995-96 - 2014

OR **95% CI**		**Women**	**Men**	**Total**
		Model 1		
No. of children	0	1.12 0.81-1.55	0.96 0.69-1.34	1.06 0.83-1.34
	1	0.89 0.74-1.08	1.22 0.93-1.59	1.02 0.85-1.21
	2-3	1.00	1.00	1.00
	4-5	1.01 0.90-1.13	0.96 0.85-1.09	0.99 0.90-1.08
	6-7	1.05 0.92-1.20	1.12 0.97-1.30	1.08 0.98-1.20
	8+	1.24* 1.00-1.53	1.16 0.97-1.39	1.20* 1.04-1.39
	Linear	1.04 1.00-1.09	1.02 0.98-1.08	1.03 1.00-1.07
		Model 2		
No. of sons	0	1.10 0.90-1.36	1.20 0.96-1.50	1.15 0.97-1.35
	1	1.00	1.00	1.00
	2	0.99 0.88-1.12	1.07 0.95-1.21	1.03 0.94-1.13
	3	0.94 0.82-1.07	0.98 0.85-1.13	0.96 0.86-1.07
	4+	1.17* 1.02-1.34	1.05 0.89-1.24	1.11 0.99-1.25
	Linear	1.02 0.98-1.06	0.99 0.95-1.04	1.00 0.97-1.04
No. of daughters	0	1.01 0.85-1.19	1.03 0.86-1.22	1.02 0.89-1.16
	1	1.00	1.00	1.00

	2	1.14* 1.01-1.29	1.14* 1.01-1.28	1.14** 1.04-1.25
	3	1.04	1.09	1.07
		0.91-1.21	0.94-1.27	0.95-1.20
	4+	1.16* 1.00-1.34	1.23* 1.04-1.45	1.19** 1.07-1.33
	Linear	1.04 1.00-1.08	1.05* 1.01-1.10	1.05** 1.02-1.09
Marital status	Married	0.84** 0.76-0.93	0.80** 0.71-0.90	0.82** 0.76-0.89
Models control for sociodemographic variables (age, gender, education, socioeconomic status), living arrangement, marital status, region and survey year *p<0.05, **p<0.01 OR; odds ratio; CI; confidence interval				

The multivariate model results broadly mimic those of the bivariate model, as controlling for sociodemographic variables had little influence on estimates. In comparison to having 2-3, having 8 or more surviving children is associated with 20% higher odds of worse SRH for older people in India (p=0.031), whilst the effect of having fewer, including 0 or 1, is similar to having 2-3. Having none versus one son is associated with 15% higher odds of having worse SRH, although the p-value is large (p=0.100) due to a small sub-sample. There is no evidence for a dose-response relationship between sons and SRH. Daughters are linearly associated with worse SRH (p=0.006 in comparison to p=0.011 when treated as a categorical variable), each additional daughter is associated with 5% higher odds of worse SRH. The effect of daughters is similar in individuals with none versus one or more sons (p=0.785, not shown). Having a spouse is also associated with better SRH for older people, with 18% lower odds of worse SRH (p<0.001). This effect increases when controlling for living arrangement, as living with a spouse only is associated with worse health (not shown).

There is no evidence for gender differences in the relationship between kin, including number of children and spouse, and older people's SRH (p>0.100). Nevertheless, having 4-plus sons is associated with 17% higher odds of worse

health in women (p=0.029) but is not associated with health in men (OR=1.05; p=0.547), potentially representing higher physiological costs of sons.

Discussion

This analysis of nationally-representative surveys reveals, for the first time, how the structure of older Indian's close kin has changed over the past two decades, and determines which kin are associated with health, thus allowing us to infer how broader sociodemographic trends will impact India's older population. Health worsened over the inter-survey period although it did not show a steady downwards trajectory. The number of children older people have is declining with time, although having no children and no sons remains rare, and having no daughters and having a spouse is becoming increasingly common. Multivariate regression results indicate that having many (8-plus) children, having daughters, and not having a son is associated with worse SRH, whilst having a spouse is associated with better SRH. There is no evidence for differences in the relationship between kin and health between women and men, indicating the importance of biosocial over physiological mechanisms.

Potential mechanisms

We first predicted that being childless or having one child is associated with worse health for both older men and women, with the rationale that these individuals will lack the traditional source of support. There is no evidence to support this. In this population it is rare to have so few children, roughly 2 and 5% of people are childless or have 1 child respectively, therefore this result may be a consequence of sparse data. On the other hand, it may be that the exceptional nature of this situation triggers coping strategies, for instance support from extended family or community members. Co-residence is a key strategy for supporting older people, and whilst living alone is higher than average for childless individuals (19% versus 4%), almost half live with other family members, indicating some support available from sources other than close kin. Evidence from China, a country with a similar system of old-age support, demonstrates that childless individuals are still likely to receive support, although the probability is almost always lower than for those with children. (Zimmer and Kwong, 2007). There are pension schemes for older people without children,

nonetheless, the pension amount is nominal, so it is unlikely that this has a large impact on older people's health (Rajan and Mishra, 2011; Dey, 2016).

We then proposed that sons would be associated with better health for older people, whilst the effect of daughters would either be smaller or negative. Our results largely support this and are in line with a previous Indian study (Sengupta and Agree, 2000); having one versus no son(s) is associated with better health, although there is no evidence for gains from having more than one, whilst having any daughters is associated with worse health. We propose that these opposing effects are a result of India's patriarchal and patrilocal society, and the resulting costs and benefits of sons and daughters. The negative effect of daughters on parents' health is similar in individuals with and without sons, perhaps indicating support from other sources, or that the negative mechanisms act at earlier stages, for instance socioeconomic stresses resulting from dowry payments.

Our results provide some weak evidence for the theory that sons are more physiologically taxing for women, as 4-plus sons was negatively associated with women's SRH, but not men's. This is in line with a study from Bangladesh, as well as others (Harrell, Smith and Mineau, 2008; Galbarczyk *et al.*, 2018), which demonstrated increasing mortality with number of sons born, when controlling for number surviving, but no effect of daughters or on men's mortality (Hurt *et al.*, 2004). If sons do in fact have a higher physiological burden, it implies that the biosocial benefits for women's health are underestimated.

Finally, we purported that having 6-plus children is associated with worse health for women, but not for men, with the rationale that women of this population experienced particularly high physiological costs due to their fertility schedule. Our results do not support this as having many (8-plus) children is associated with worse health for both women and men. This is in line with several studies that have demonstrated an association between high parity and negative health outcomes for men (Grundy and Tomassini, 2007; Barclay *et al.*, 2016; Högnäs *et al.*, 2016; Barclay and Kolk, 2019), and may be because biosocial mechanisms act differently, therefore masking any female-specific burden. For instance, in the US, there is evidence that mothers receive more support (Silverstein, Gans and Yang, 2006).

As in other natural fertility populations, the “healthy pregnant woman effect” may offset the negative effect of having children (Hurt *et al.*, 2004; Hurt, Ronsmans and Thomas, 2006). In a systematic review of natural fertility populations that revealed mixed results, the one study that controlled for woman’s health demonstrated a trend of rising mortality (Doblhammer and Oeppen, 2003; Hurt, Ronsmans and Thomas, 2006). The healthy pregnant woman effect is likely exacerbated in these analyses, as the variables relate to children surviving rather than born. As one might expect the children of less healthy women to have higher mortality, older women in poorer health will have fewer surviving children, thus inflating the positive association between children and good health.

The similar effect of children on men and women’s health, and the differing effect of sons and daughters, indicates biosocial mechanisms at play. Raising children, for instance financing their living costs, education, marriages, corresponds to a heavy socioeconomic burden for parents, and our results indicate that these costs outweigh the benefits of children at child number 8. There is evidence that children are more likely to be associated with negative health outcomes in parents of low socioeconomic groups (Dribe, 2006), as parents with fewer resources must adapt, for instance by ignoring their own needs e.g. nutritious foods. Having many children also likely results in high psychosocial stress across the life-course and may correspond to higher intra-family conflict. Nevertheless, having 8 or more surviving children is high, and already uncommon in 1995-96, thus the impact in the population is limited.

Finally, our results reveal strong evidence for a positive effect of being married on older people’s health, with similar benefits for women and men. This contradicts some evidence of larger effects for women in India (Sudha *et al.*, 2006; Perkins *et al.*, 2016; Stewart Williams, Norström and Ng, 2017), but is in line with other studies from India and Bangladesh (Rahman, 2000; Hirve *et al.*, 2012), and is very similar to that of western populations (Manzoli *et al.*, 2007). It is likely that marriage benefits older men and women via different pathways, although the loss of emotional support and the impact of distress from losing a spouse may be significant for both.

Implications

Our results suggest that current sociodemographic trends will not have a negative effect on the health of India's older population. Whilst numbers of children are declining, there are marginal gains from having many children, in fact high numbers tend to be associated with worse health. Being child- or son-less remains uncommon, and people are increasingly likely to have a spouse, which is associated with better health. The similar effects by gender, signifying the importance of biosocial mechanisms, imply that current trends will be beneficial for both men and women.

Nevertheless, changes in the size and composition of families will likely influence how old-age support is provided, for instance who provides different forms of support. In India, as elsewhere, supporting aging relatives can result in high physical, psychological and financial burden. Primary caregivers to dependent elders in rural India are estimated to provide 40 hours of care a week, resulting in a high financial and caregiver burden (Brinda *et al.*, 2014), whilst households with an older person are at higher risk of catastrophic health expenditure (Pandey *et al.*, 2018). There is little evidence to how support provision is allocated within families in India, but it is likely that having fewer relations will result in a higher burden for those providing support. For instance, in China the probability of receiving financial support rises with numbers of children, demonstrating a degree of support allocation between siblings (Zimmer and Kwong, 2007).

Looking forward, we expect the largest changes to occur over the next few generations as fertility has dropped considerably since the fertility period of India's current older population, reaching below replacement in some states (e.g. Total Fertility Rate=1.6 in Tamil Nadu) (Registrar General & Census Commissioner of India, 2012). These parents will have far fewer children available to support them in their old age.

We also expect the prevalence of not having a daughter to continue rising, as son preference persists and fertility falls (Dubuc and Sivia, 2018). To illustrate, trends in the gender composition of children, stratified by family size, reveal a rising propensity of small families to be composed of sons (an increase from 60 to 70% of 1-child families, and 50 to 55% of 2-3 child families (figure 4; appendix)). Whilst our results indicate daughters are associated with worse health for older parents, a

decline in the presence of daughters has its own social implications. For instance, daughters are typically perceived as more caring and attached in comparison to sons, as a reliable source of emotional support, and able to help in times of need (Diamond-Smith, Luke and McGarvey, 2008; Allendorf, 2012; Ugargol and Bailey, 2018). In addition, daughters tend to be key sources of help with domestic tasks and as carers for younger siblings ("helpers in the nest") (Bereczkei and Dunbar, 2002; Hames and Draper, 2004), which is important for reducing the domestic workload of mothers (Boyd, 1989), potentially improving their autonomy and labour market participation (Heath and Tan, 2018).

Finally, although there is no evidence for changing relationships between kin and health in this population, we do not expect the relationships to remain constant. Firstly, results indicate that biosocial mechanisms are of primary importance in this population. Social costs and benefits will likely fluctuate alongside India's transforming society. For instance, despite being illegal, the practice of dowry is rising (Srinivasan, 2005), which may worsen the association between daughters and parents' health, whilst migration may reduce the ability of sons to support their parents. More positively, the spread of technology could make providing monetary or emotional support from a distance easier. Secondly, we expect large family sizes to be increasingly associated with negative health outcomes as they become concentrated in lower socioeconomic groups, who tend to have worse health. We do not expect that this is significant for the current older population, as evidenced by the minor effect of adjusting for socioeconomic variables in the model. Finally, the filial norms that restrict support from daughters may weaken as people adapt to changing family structures, and if women become more economically independent because of their participation in the labour market. Whilst this might benefit older people, it has the potential to increase burden for children. There is qualitative evidence of this occurring already (Allendorf, 2012), for instance in a focus-group conducted by the author in Chennai (2018, manuscript in preparation), female teachers stated the following:

> M: …Would you say you are able to support your parents if you want to? R: Yeah now the trend has changed... R: Yes changed. R: Changed. R: ...now we are able to support, we are able to move on faster with them, earlier it was

not like this but now because of education, because of er women coming out for working, now the situation has changed, now equally how we look after our in-laws we look after our parents. R: Maybe in a few years everything will be changed! R: It has now become equal. R: Equal! R: Even in my in-laws they are not accepting that my mother is with me. But I am ready to break up this relationship for this. They I am telling like that. M: And your husband? R: Starting, he was also like that only. But nowadays he understands, OK... Because he also having only daughters.

Thus, there is evidence that norms and practices are adapting to changing family structures and women's roles, and that children are providing more support, i.e. to both their parents and their in-laws.

Limitations

This study has a few limitations. Firstly, it describes past trends and associations to infer how sociodemographic trends will affect health of India's older population. Although this is simplistic in comparison to projection-based methods (Pickard *et al.*, 2011; Zeng *et al.*, 2015), we propose that the variable and socially driven nature of the relationships make projections unsuitable. Instead, research should focus on quantifying trends and elucidating the (potentially changing) relationships between kin, social support and older people's health.

Secondly, the variables available are basic and we are therefore unable to examine specific mechanisms. For instance, numbers of surviving children do not necessarily correspond to contact with or receipt of support (Grundy and Read, 2012), thus data on proximity to children, and amounts, type, and sources of support would be preferable. Data on fertility histories such as age at births, birth intervals, and total parity would be beneficial for elucidating the physiological versus biosocial pathway. Thus, whilst we can establish the relationships and broadly estimate whether biosocial or physiological mechanism are at play, we are unable to clarify further.

There is evidence that self-rated health is associated with socioeconomic status and education, as individuals with a higher level of health awareness will assess their health more critically (Sen, 2002; Bago d'Uva, O'Donnell and Van

doorslaer, 2008; Xu and Xie, 2016; Cullati *et al.*, 2018). Nevertheless, as the older population was increasingly educated with time (table 6; appendix), we might expect health to worsen consistently if trends are a consequence of socioeconomic change, which it does not, and estimates adjusting for education are very similar (not shown).

Thirdly, the regression sample corresponds to a very broad population, Indians aged 60 and above living between 1995-96 and 2014, and although there is no evidence that relationships have changed over time, this grouping may hide some other variation. For instance, kinship structures differ across the north-south divide in India, with less exogamy and more consanguineous marriages in the south (Desai, 2005). Consequently, it has been theorised that stronger ties remain with a daughter's natal kin in the south (Dyson and Moore, 1983; Rahman and Rao, 2004), which would allow more support provision. This may underlie the contrasting results from the 1993 survey in southern India, which revealed an association between having a daughter and good SRH of fathers (Sudha *et al.*, 2006). Nevertheless, there is no evidence for a difference in the effect of having none versus one or more daughters in the south in comparison to the north (p=0.183, not shown) in this population. We focused on gender to elucidate potential mechanisms; future research could assess the relationship between kin and health in different socioeconomic or religious groups.

Finally, we examined the effect of gender to assess potential, biosocial or physiological, mechanisms between kin and health. This assumes that biosocial mechanisms act similarly between men and women, which may not be valid. A study in Egypt revealed a larger negative effect of parity on functional health for older men, which was hypothesised to be due a higher burden resulting from their role as economic provider (Engelman *et al.*, 2010). There is little evidence on the details of support provision in India, so it remains unclear whether our assumption holds.

This leads on to a key issue in the research of kin, support, and older people in India. Beyond basic descriptions of sons providing financially and daughters-in-law caregiving, there is very little evidence to how dependent older people are supported. It is important to understand this, so to predict how sociodemographic trends will affect both the older population and their families. For instance, how is support allocated between children, how are extended relatives involved, and how do

families, particularly women, manage support around employment? India's old-age support system, and thus wellbeing of the older population, is reliant on the will and ability of families to care, therefore an increase in family's burden might imply a need for alternative support arrangements. Indians still strongly prefer to co-reside with and be supported by their families, sons in particular (Desai, 2005), so support for families, for instance by tackling out-of-pocket healthcare payments (Pandey *et al.*, 2018), may be a more appropriate way to maintain support provision whilst reducing the corresponding burden.

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Appendix

Table 4: Bivariate association between kin and poor self-rated health in India's older population, by gender (1995-96 – 2014)

		Gender					
		Women		**Men**		**Total**	
		%	**95% CI**	**%**	**95% CI**	**%**	**95% CI**
No. of surviving children	0	26.6	20.5-32.7	20.3	15.0-25.5	23.9	19.6-28.2
	1	22.5	19.0-26.0	22.2	17.7-26.7	22.4	19.4-25.4
	2-3	23.2	21.6-24.8	18.0	16.5-19.4	20.6	19.4-21.7
	4-5	23.9	22.5-25.3	19.2	17.9-20.5	21.5	20.5-22.6
	6-7	25.6	23.5-27.7	23.2	20.8-25.7	24.5	22.9-26.0
	8+	29.8	25.5-34.0	24.3	21.0-27.7	27.1	24.2-29.9
No. of sons	0	25.2	21.7-28.8	22.1	18.4-25.8	23.9	21.2-26.5
	1	24.2	22.5-26.0	18.2	16.7-19.7	21.4	20.1-22.6
	2	23.3	21.8-24.8	19.6	18.2-21.1	21.4	20.2-22.5
	3	22.5	20.6-24.4	20.0	18.0-22.1	21.2	19.8-22.7
	4+	28.2	25.8-30.5	22.2	20.0-24.4	25.2	23.5-27.0
No. of daughters	0	23.5	20.7-26.3	18.6	16.0-21.2	21.1	19.1-23.2

	1	22.3	20.7-23.9	17.9	16.5-19.4	20.1	19.0-21.3
	2	25.4	23.7-27.1	19.9	18.4-21.4	22.7	21.5-23.9
	3	24.3	22.0-26.5	21.1	18.9-23.3	22.7	21.0-24.4
	4+	26.7	24.2-29.2	23.9	21.1-26.7	25.3	23.5-27.2
Marital status	Unmarried	28.1	26.9-29.3	26.5	24.5-28.5	27.7	26.6-28.7
	Currently married	18.7	17.5-19.9	18.2	17.3-19.1	18.3	17.5-19.2
CI; confidence interval							

Table 5: Ordinal regression of worse self-rated health and kin by survey year for India's older population

OR **95% CI**		**1995-96**	**2004**	**2014**
		Model 1		
No. of surviving children	0	1.20 0.84-1.71	1.04 0.76-1.43	1.02 0.67-1.53
	1	1.18 0.84-1.66	1.02 0.82-1.27	0.97 0.74-1.27
	2-3	1.00	1.00	1.00
	4-5	1.05 0.90-1.22	1.04 0.95-1.14	0.92 0.77-1.08
	6+	1.07 0.91-1.26	1.05 0.95-1.16	1.24* 1.02-1.51
	Linear	1.01 0.95-1.07	1.02 0.98-1.06	1.05 0.97-1.13
		Model 2		
No. of surviving sons	0	1.05 0.77-1.42	0.98 0.82-1.17	1.30 0.99-1.70
	1	1.00	1.00	1.00
	2	1.00 0.86-1.17	0.98 0.89-1.08	1.08 0.91-1.27
	3	1.03 0.88-1.21	0.94 0.84-1.05	0.92 0.75-1.14
	4+	1.04 0.87-1.24	1.05 0.93-1.19	1.22 0.94-1.59
	Linear	1.01 0.96-1.07	1.01 0.97-1.04	1.00 0.93-1.07
No. of surviving daughters	0	1.16 0.89-1.51	1.06 0.91-1.23	0.99 0.80-1.21
	1	1.00	1.00	1.00
	2	1.04 0.90-1.20	1.12* 1.02-1.23	1.21* 1.02-1.45

	3	1.07 0.91-1.27	1.04 0.93-1.17	1.08 0.85-1.36
	4+	1.10 0.92-1.31	1.06 0.94-1.20	1.40** 1.11-1.76
	Linear	1.02 0.97-1.07	1.01 0.98-1.05	1.08** 1.02-1.14
Marital status	Married	0.76** 0.68-0.86	0.89* 0.82-0.98	0.81** 0.70-0.94
Models control for sociod SES), living arrangement, *p<0.05, **p<0.01 CI; confidence interval; O	mographic variables (age group, gender, education, marital status, region ?; odds ratios			

Table 6: Background characteristics of the older Indian population, by survey year (1995-96 - 2014)

	Survey year					
	1995-96		2004		2014	
Age (years)	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**
60-64	31.8	30.9-32.8	36.3	35.5-37.0	36.0	34.7-37.4
65-69	30.7	29.8-31.5	29.1	28.4-29.7	28.5	27.3-29.7
70-74	19.7	19.0-20.5	18.7	18.1-19.3	18.6	17.5-19.6
75-79	8.6	8.0-9.1	7.6	7.2-7.9	8.7	7.9-9.5
80+	9.2	8.6-9.8	8.4	8.0-8.9	8.2	7.5-8.9
Female	50.6	49.8-51.3	50.0	49.4-50.6	50.8	49.7-51.9
Education						
Below primary	80.9	79.9-81.8	76.4	75.5-77.3	68.6	67.1-70.0
Primary	8.1	7.6-8.7	9.1	8.6-9.5	9.4	8.5-10.2
Middle to secondary	9.2	8.6-9.8	11.5	10.9-12.1	16.1	15.1-17.1
Above secondary	1.8	1.6-2.0	3.0	2.7-3.3	6.0	5.3-6.7
Socioeconomic Status						
1	21.5	20.4-22.6	29.4	28.4-30.4	20.7	19.3-22.2
2	22.1	21.1-23.2	19.1	18.4-19.9	15.1	13.9-16.3
3	19.6	18.6-20.5	17.1	16.4-17.9	16.9	15.6-18.2
4	19.4	18.4-20.3	16.0	15.3-16.7	19.6	18.3-21.0
5	17.4	16.3-18.5	18.3	17.4-19.2	27.6	26.0-29.1
Living arrangement						
Alone	3.5	3.2-3.9	4.8	4.4-5.1	3.8	3.3-4.4
Spouse only	9.7	8.9-10.5	11.7	11.1-12.3	15.0	13.7-16.3
Children and grandchildren	60.5	59.4-61.7	57.7	56.9-58.6	58.0	56.3-59.7
Children	19.3	18.4-20.2	19.7	19.1-20.4	18.8	17.4-20.2
Others	6.9	6.4-7.5	6.0	5.6-6.5	4.4	3.6-5.1

Region								
South	24.9	23.0-26.8		25.4	24.1-26.7		28.8	27.0-30.7
West	15.7	14.2-17.2		16.1	14.8-17.3		14.2	13.0-15.5
Central	25.9	24.1-27.8		23.1	21.8-24.3		20.1	18.5-21.6
East/North east	21.6	20.0-23.2		22.7	21.5-23.9		23.4	21.7-25.1
North	11.9	10.7-13.1		12.8	11.8-13.8		13.4	12.2-14.7
CI; confidence interval								

Figure 4: Son composition of children, by total number of children (1995-96 - 2014)