Fathers favour sons, mothers don't discriminate: a study of sex-biased parental care in north-western Tanzania

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Abstract (199 words)

Variation in parental care by child's sex is evident cross-culturally. Evolutionary theory provides a functional explanation for this phenomenon, predicting that parents will favour specific children if this results in greater subsequent fitness pay-offs. Here, we explore evidence for sex-biased parental care in a high-fertility, patriarchal and polygynous population in Tanzania, predicting that both mothers and fathers will favour sons in this cultural setting. Our data come from a cross-sectional study on 808 children from two rural communities in north-western Tanzania. We focus on early childhood (under age 5), a period with high mortality risk which is fundamental in establishing later-life physical and cognitive development. Examining multiple measures of direct care provision (washing, feeding, playing with, supervising, co-sleeping, and caring for when sick) we demonstrate that fathers favour sons across multiple measures, while maternal care is both more intensive and unrelated to child sex. We find no difference in parental care between girls and boys with regards to the allocation of material resources, the duration of breastfeeding, and in terms of parental marital and co-residence status. This bias towards sons may result from higher returns to investment for fathers than mothers and local gender norms about physical care provision.

1. Introduction

A broad principle of parental investment theory posits that natural selection will favour equal parental care for sons and daughters if rearing both sexes is equally costly, as each sex provides exactly half the genes for all future descendants (Fisher, 1930). However, the costs and benefits of investment in each sex are rarely uniform (Hamilton, 1967; Trivers & Willard, 1973), and discriminatory parental care by offspring sex is observed across human cultures. Parental investment is defined as any allocation of resources which benefits offspring at a cost to a parent's ability to invest in other components of fitness, while parental care more broadly refers to any parental trait that enhances the fitness of offspring, and is likely to have originated and/or to be maintained for that function, without necessarily being costly to the parent (Royle, Smiseth, & Kölliker, 2012; Trivers, 1972). Parental care is the more appropriate term when costs to parental fitness are not directly estimated. The focus of this paper is on post-natal parental care, as opposed to biases in sex ratio at birth. Sex-biases in post-natal care may include such factors as discriminatory feeding, supervision, expenditure on health care and schooling, along with differential allocation of resources throughout life, including the transfer of inheritance.

When sex-biased parental care is observed it is most commonly biased in favour of sons (Hartung et al., 1976; Khera, Jain, Lodha, & Ramakrishnan, 2014; Williamson, 1976). Son-preference is perhaps most evident in some East and South Asian societies (Das Gupta et al., 2003; Murphy, Tao, & Lu, 2011) but has also been widely reported in sub-Saharan Africa (Campbell, 1991; Fayehun, Omololu, & Isiugo-Abanihe, 1997; Frempong & Codjoe, 2017). Parental biases favouring sons will be adaptive when the marginal returns to investing in sons is greater than for daughters (Keller, Nesse, & Hofferth, 2001; Veller, Haig, & Nowak,

2016). This scenario may especially characterize contexts where variability in male fitness is extended via polygynous marriage (Clutton-Brock, Albon and Guinness, 1981; Leimar, 1996; Irwin *et al.*, 2006; but see Brown, Laland and Borgerhoff Mulder, 2009). From a proximate economic viewpoint, investing in a son may also maximise chances of future financial and social returns and support in old age if men are valued over women for providing family labour and financial security for parents throughout their life-course (Becker & Tomes, 1976; Mutharayappa, 1997).

On the other hand, in some populations parents invest more in daughters (Alexander, 1974; Cronk, 1989; He, Wu, Ji, Tao, & Mace, 2016). This has been largely explained through the concept of 'local resource enhancement', which indicates that a disparity in the productivity of boys and girls as helpers in the household may bias favour towards the more helpful sex when that family does not have a sufficient number of that sex, whether male or female (Pen & Weissing, 2000; Quinlan & Quinlan, 2005). In societies that favour daughters, girls tend to partake more than boys in activities that benefit the family economically and/or help more with housework and caring for younger children (Bereczkei & Dunbar, 1997, 2002; Hames & Draper, 2004; Margulis, Altmann, & Ober, 1993). This has been recorded among the American Hutterites (Margulis et al., 1993), communities in Tibet and China (Childs, Goldstein, & Wangdui, 2011; Du & Mace, 2017; Zhan & Montgomery, 2003) as well as the !Kung in Botswana (Hames & Draper, 2004).

Complicating the study of parental care, previous studies have often used on indirect measures to quantify discriminatory treatment of sons and daughters. Such indirect measure include self-reported preferences of parents (Brunson, 2010; Cronk, 1991a; Du & Mace, 2017); child outcomes such as health and mortality as proxies for differential

investment (Arnold, Choe, & Roy, 1998; Chen, Huq, & D'Souza, 1981; Klasen, 1996; Svedberg, 1990); along with skewed sex ratios at birth and/or other ages (Guilmoto, 2012, 2015). These measures may be problematic for a number of reasons. There are often discrepancies between stated sex preferences and who parents actually invest in: one study in Amdo Tibet found girls were favoured due to their increasing economic value in a community where norms favour males (Du & Mace, 2017); and similar discrepancies have been documented among the Mukogodo in Kenya, where there is a dissonance between cultural norms, which favour boys, and parental behaviour which is daughter-biased (Cronk, 1991a). Furthermore, differences in the wellbeing or survival of males and females vary independently of parental care in non-trivial ways. Male and female developmental trajectories are distinct, and males are generally subject to higher neonatal and infant mortality than females independently of parental behaviour (Wells, 2000). Likewise, educational attainment is now higher for females in most high-income populations, but this may reflect male vulnerabilities to mental health issues or other factors which favour school dropout (e.g. incarceration) rather than higher parental investment in daughters (Grant & Behrman, 2010; McDaniel, 2012). Finally, it is important to note that natural selection is anticipated to act independently on sex-ratio biasing and post-natal investments (Veller et al., 2016), so that evidence of one (e.g. a male biased sex ratio) should not be taken as evidence of the other (e.g. indication that male offspring are treated differently by parents after birth).

Quantifying differences in actual parental behaviour is thus preferable, especially behaviours most likely to be both costly to parents and beneficial to offspring (and so fitting the formal definition of parental investment) (Clutton Brock, 1991; Royle et al.,

2012). Such measures include conspicuous transfers of capital (e.g. at inheritance – Hartung et al., 1976; Hrdy & Judge, 1993) or observations of direct care provision (Baker & Milligan, 2016; Bereczkei & Dunbar, 1997; Cronk, 1991b; Lawson & Mace, 2009; Nikiforidis, Durante, Redden, & Griskevicius, 2018). In this paper, we explore evidence of sex-bias in post-natal parental care in a rural north-western Tanzanian population. We focus on children under 5-years because providing adequate care at this age is crucial for child health (WHO, 2018). Children are vulnerable during this period, experiencing a high rate of preventable mortality [41 deaths per 1000 live births globally in 2016 (WHO, 2017)]. Additionally, this life-stage sets future trajectories of child growth; among other complications, poor feeding practices and malnutrition can result in stunting, wasting, underweight or overweight and obesity, which may have health implications throughout the life-course (Almond & Currie, 2011; Maluccio et al., 2009; Palloni, 2017). We consider four dimensions of parental care: (i) allocation of material resources; (ii) direct care provision (washing, feeding, playing with, supervising, co-sleeping, and caring for when sick); (iii) breastfeeding duration (a well-established determinant of child survival and nutrition outcomes (Sellen, 2007) (D.W. Lawson, Alvergne, & Gibson, 2012; Sellen, 2007); and (iv) parental marital status and co-residence, which we treat as a commitment to parental care, especially from fathers (Dahl & Moretti, 2008) (see Dahl and Moretti, 2008).

Though we know daughters play a valuable role in contributing to household work in our study population (Hedges, Sear, Todd, Urassa, & Lawson, 2018), we expect that parents will bias care towards their sons across all measures. Substantial value is placed on men in many Tanzanian communities, visible in traditionally practised patrilineal systems of marriage and wealth inheritance among local peoples e.g. marital systems are usually

122 extended patrilocal, with women moving into their husbands' households after marriage;
123 and wealth and land is most often passed primarily from father to son (Ezer, 2002).
124 Investment biases favouring sons are usually present in such contexts, especially where
125 polygynous marriage is common (Das Gupta et al., 2003; Hartung et al., 1976; Mace, 1996;
126 Williamson, 1976). However, we are not aware of many studies of sex-biased investment.
127 One study in the Mbeya Region of south-western Tanzania, documented men's preference
128 for sons vs daughters and resultant contraceptive behaviour, reporting men to have a
129 strong inclination towards having sons over daughters (Mwageni, Ankomah, & Powell,
130 2001).

131 A particular tenet of evolutionary parental investment theory widely explored in the
132 literature is the Trivers-Willard Hypothesis (TWH). This suggests parents in 'good condition'
133 (e.g. resource-rich) will benefit more from investing in offspring of the sex that has greater
134 variation in reproductive success (i.e. often males); and parents in 'poor condition' (e.g.
135 resource-poor) will benefit more from investing in offspring of the other sex (i.e. often
136 females) (Trivers & Willard, 1973; Veller et al., 2016). High levels of fertility and polygynous
137 marriage in Tanzania (Total Fertility Rate: 6.4 births per woman; 18% of married women in
138 the country have at least one co-wife (Ministry of Health et al., 2016) indicate both higher
139 variation in male than female reproductive success as well as more opportunities for men to
140 translate invested resources into reproductive success. Given this, we predict that biases in
141 parental investment in our study population may be dependent on family wealth, so that
142 parents in resource-rich households will have a son-bias, whereas parents in resource-poor
143 households will favour daughters.

Our study has two major strengths. First, we considered a wide range of measures of parental care within the same population. Second, we explored parental care from both mothers and fathers. Most previous studies either focused on mothers, or investment from both parents, neglecting the role of fathers even though parental behaviour (and the subsequent fitness returns to investment) may vary by *both* the child's and parent's sex (as documented in some high-income populations: Lawson & Mace, 2009; Nettle, 2008; Nikiforidis et al., 2018).

2. Data and Methods

2.1. Data Collection

Our data come from two rural communities (one rural but rapidly urbanizing town and one rural village) in north-western Tanzania situated within the bounds of the Magu Health and Demographic Surveillance Site (HDSS), which has been active in the area since 1994 (Kishamawe *et al.*, 2015; see also Hedges *et al.*, 2018). The area is primarily Sukuma. Although Tanzania is home to considerable ethnic diversity, the Sukuma are the largest ethnic group in the country, comprising approximately 17% of the national population (Malipula, 2016). We randomly sampled 743 households for the requirements of a larger project studying the wellbeing of women aged 15-35 years and their children (see Schaffnit *et al.*,in press). The data used for this paper comes from surveys conducted in the 506 households that had a resident child aged under 5 years, with 808 children surveyed. Each household survey recorded household membership, size and composition, and the demographic and socio-economic characteristics of the household head and all household members, including members' relationship to household head, household food insecurity and land ownership. All indicators used in this paper that pertain to the child and the child's

parents were then measured via a child survey directed to either the child's biological mother or primary guardian if the mother was unavailable. All interviews were carried out in Swahili or Sukuma using Open Data Kit (ODK) Collect software on electronic devices. Ethical approval was granted by LSHTM (13809), UCSB (1-17-0405), and NIMR (MR/53/100/463).

2.2. Variables Used and Data Analysis

Parental care was measured across several dimensions (our dependent variables) and associations with sex of the recipient child (the primary independent variable) were analysed using logistic regression and survival analysis depending on the measure of care (see below). Treating child's sex as an exogenous variable (i.e. there are likely to be few confounders of the associations we test), in all models, we adjusted only for child's age (continuous measure) and age-squared. We did not run multi-level models as we surveyed an average of 1.7 children per household and fixed and random effects both may be overestimated when clusters are unbalanced and sparsely populated i.e. less than 2 cases per level (Clarke, 2008).

Allocation of material resources was captured in a binary variable indicating whether the child had received resources from mothers and fathers (whether co-resident or not co-resident with the child) in the 3 months preceding the survey (Mothers: n=807, 1 refusal; Fathers: n=807, 1 'don't know'). Resources could include food, medicine, clothes, money, household goods or 'other'. Direct care was captured in six binary variables (n=808 for both parents unless stated otherwise) indicating whether mothers and fathers had washed, fed or cooked for, played with, supervised or monitored, slept in the same room as the parents (Mothers: n=807, 1 missing; Fathers: n=808), or cared for the child if sick in the two weeks

preceding the survey (215 children had been sick in this time period (girls: 103; boys: 112); n=215 for both parents). Children whose mothers or fathers were not alive at the time of survey (Mothers: n=6; Fathers: n=9) were excluded from the analysis. Logistic regression models were used to test for associations between each measure of parental care and child's sex.

Mothers' investment in breastfeeding was measured in two ways. Firstly, for children who had stopped breastfeeding, we measured time spent exclusively breastfeeding (i.e. a time period during which the child was given no other drink or food apart from breastmilk). A binary variable indicated "Less than 6 months" or "6 or more months" (n=541; excluded: 5 children whose mothers had died, 5 who had never been breastfed, an additional 3 who had never been exclusively breastfed, 14 for whom the respondents did not know if they had ever been exclusively breastfed, and the 240 babies who were still breastfeeding at time of survey). Secondly, for all children, a continuous variable to indicate at what age, in months, the child stopped breastfeeding completely (n=798; excluded: 5 children who had never been breastfed and 5 whose mothers had died. All non-resident mothers (n=74) had breastfed their children so were included in the analysis). The 240 children still breastfeeding at time of survey were included in the analysis as right-censored cases (see below).

A logistic regression model was used to explore whether girls had higher odds of terminating exclusive breastfeeding before six months. Discrete-time event history analysis was used to test for an effect of child's sex on duration of overall breastfeeding: heaping of events at ages 6, 12 and 18 months meant that discrete-time survival analysis was the most appropriate method to use.

213 Two indicators measured parental relationship status. Firstly, whether the child's parents
214 were married or divorced, regardless of co-residence or marital type (i.e. polygynous or
215 monogamous). This included only those children whose parents were currently married
216 (n=555) and those whose parents were separated or divorced (n=98), with a total sample of
217 653 children. Children were excluded if the respondent did not know (n=1) or refused to
218 answer (n=1); if one or both parents were not alive (n=14); or if the parents were not in a
219 relationship during the survey period and had never married and those who were in a
220 relationship but unmarried. Secondly, parental relationship status was measures as
221 whether the child's parents co-resided or not, regardless of marital status (n=793; excluded:
222 if one or both parents not alive (n=14); refusal (n=1)).

223 We fit multivariate logistic regressions to examine the association between child's sex and
224 parental marital status or co-residence. Considering we do not have data on children's elder
225 siblings, whose sex may impact parental relationships, we also ran a sensitivity analysis
226 restricting our sample to only first children of parents (n=101 for marital status and n=166
227 for co-residence).

228 To test for the TWH we ran our models for each type of parental care, including a variable
229 for household food insecurity as a proxy for socio-economic status, and an interaction term
230 between food insecurity and child's sex. As food insecurity levels in this population are high
231 and there is a substantial variation in livelihoods between the village and town residents,
232 we considered the food insecurity index to be a more accurate representation of resource
233 availability than asset ownership (see Hedges *et al.*, 2018). Food insecurity was measured
234 using the Household Food Insecurity (Access) Scale (Coates, Swindale, & Bilinsky, 2007),

which records whether the household experienced problems with accessing food in the past month. For further information on testing for a TWH see SM1.

3. Results

3.1. Household and Child Characteristics

There was an average of 7.7 household members and 1.7 children under age 5-years resident in each of the 506 households containing at least one child **(Table 1)**. The majority of households were of Sukuma ethnicity (90%), identified with a form of Christianity (Roman Catholic: 36%; Other Christian 36%) and had a male household-head (81%). Most households-heads were educated to primary level (66%) with very few having progressed further (11%) and the remaining had no education (22%; don't know=1%). A little more than half of the household-heads listed farming as their main occupation (55%) followed by trading (21%). A large percentage of households scored high on food insecurity; 57% were categorised as severely insecure and 21% as moderately insecure. An equal proportion of girls and boys were surveyed with ages ranging from 7 days old up to 5 years. Whereas almost all children resided with their biological mothers (90%), one-third did not live with their biological fathers (of those with a living father). Almost one-third of children's biological parents were not married to each other, and the most common reason for this was separation or divorce.

Table 1 - Household and Child Level Characteristics

	Girls	Boys	Total
Number of households with children 0-5 years			506
Number of total children 0-5 years	397	411	808
Household Characteristics			
Household size - mean (min, max)			7.67 (3, 25)
Number of 0-5s in household - mean (min, max)			1.75 (1, 7)
Food insecurity - n (%)			
Food secure			94 (18.61)
Mildly food insecure			19 (3.76)
Moderately food insecure			106 (20.99)
Severely food insecure			286 (56.63)
Child Characteristics			
Age Continuous - mean (min, max)	2.44 (0, 5)	2.42 (0, 5)	2.43 (0, 5)
Age in Years - n (%)			
0-1 years	76 (19.14)	83 (20.19)	159 (19.68)
1-2 years	78 (19.65)	78 (18.98)	156 (19.31)
2-3 years	81 (20.40)	85 (20.68)	166 (20.54)
3-4 years	94 (23.68)	90 (21.90)	184 (22.77)
4-5 years	68 (17.13)	75 (18.25)	143 (17.70)
First Child of Biological Father - n (%)			
Yes	89 (23.06)	78 (19.65)	167 (21.33)
No	291 (75.39)	314 (79.09)	605 (77.27)
Don't know	6 (1.55)	5 (1.26)	11 (1.40)
Breastfeeding Duration* - n (%)			
0-5 months	12 (4.33)	6 (2.10)	18 (3.20)
6-11 months	18 (6.50)	19 (6.64)	37 (6.57)
12-17 months	114 (41.16)	134 (46.85)	248 (44.05)
18-23 months	84 (30.32)	83 (29.02)	167 (29.66)
23-26 months	49 (17.69)	44 (15.38)	93 (16.52)
Parent Characteristics			
Mother's Residence/Death - n (%)			
Lives in household	361 (90.93)	367 (89.29)	728 (90.10)
Does not live in household	32 (8.06)	42 (10.22)	74 (9.16)
Dead	4 (1.01)	2 (0.49)	6 (0.74)
Father's Residence/Death - n (%)			
In the household	265 (66.75)	282 (68.61)	547 (67.70)
Not in the household	123 (30.98)	117 (28.47)	240 (29.70)
Dead	4 (1.01)	5 (1.22)	9 (1.11)
Don't Know / Refusal	5 (1.26)	7 (1.70)	12 (1.49)
Parents' Marital Status - n (%)			
Married	275 (71.24)	280 (70.53)	555 (70.88)
Not Married	110 (28.50)	116 (29.22)	226 (28.86)
Don't Know / Refusal	1 (0.26)	1 (0.25)	2 (0.26)

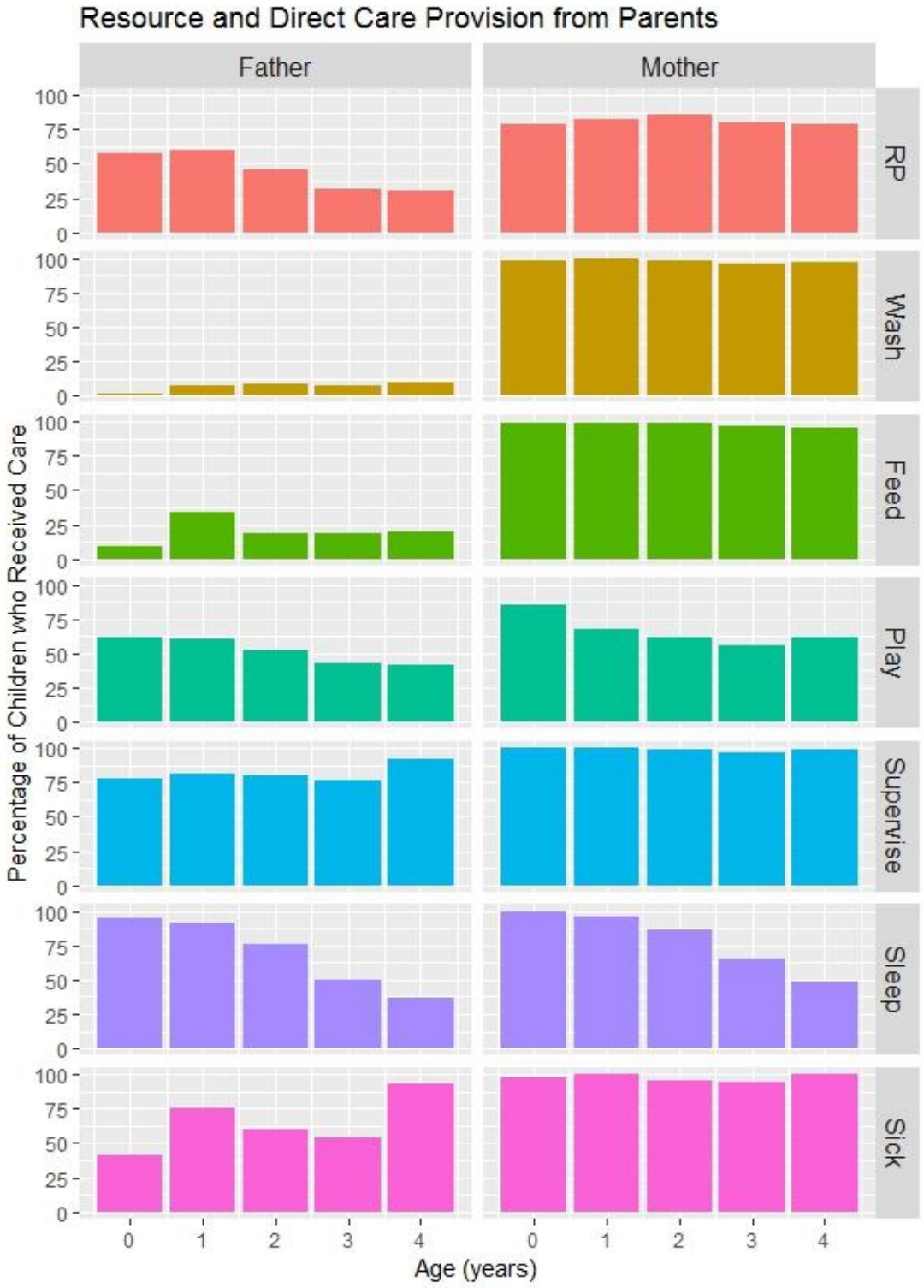
**among weaned children only (n=563)*

3.2. Resource Allocation and Direct Care Provision

A breakdown of resource and direct care provision from by child's age and parent's gender is presented in **Figure 1**. Mothers were equally likely to have provided resources in the 3 months preceding the survey than fathers. A majority of children had received resources from their mothers and fathers in this time period (81% from mothers; 81% from fathers). All children with a resident father had received resources from him. In contrast, among children with non-coresident fathers (n=240; 30%) 45% had received resources in the past 3 months. Due to the lack of variation in direct resource provisioning by fathers among children with resident fathers, we restricted analyses regarding resource provision from fathers to children with non-resident fathers only. There was no evidence of a difference between resource provision to boys and girls from either parent **(Table 2; Supplementary Tables S1.1 and S1.2).**

With regards to direct care, mothers more often provided all six types in the 2 weeks preceding the survey compared to fathers **(Figure 1)**. Very few non-co-resident mothers and fathers provided any of the six types of this care to their children this time period and so we excluded these parents from our analysis: non-co-resident mothers - washing (n=2, 3%), feeding (n=5, 7%), playing with (n=2, 3%), supervising (n=4, 5%), co-sleeping (n=2, 3%) and caring for when sick (n=1, 10%); non-coresident fathers - washing (n=0), feeding (n=8, 3%), playing with (n=19, 8%), supervising (n=18, 8%), co-sleeping (n=11, 5%) and caring for when sick (n=7, 10%).

Figure 1 – Percentage of children who experienced resource allocation/provisioning (RP) in past 3 months and direct care in past two weeks from their biological fathers and mothers, by child's age (years). Direct care is from co-resident parents only (Mothers: n=728; Fathers: n=547); resource provision (RP) is from alive mothers (n=801; excluded 'refusal' n=1) and non-resident fathers n=239; excluded 'don't know' n=1); caring for sick children limited to children who had been sick in past two weeks (n=215).



Sons had higher odds of receiving all six types of direct care from resident fathers than daughters. The difference in odds was statistically significant (at $p<0.05$) for washing, feeding, and supervising the child as marked in **Figure 2**. For the other activities, effect sizes were comparable but in all cases 95% confidence intervals cross 1 and the p-value was greater than 0.1 **(Table 2; Supplementary Figure S1; Supplementary Tables S2.1-2.12).** The results from resident mothers were inconsistent, with little visible difference in care provision between boys and girls **(Figure 2)**. Logistic regression models showed confidence intervals for odds ratios to cross 1 for all six types of direct care and p-values were greater than 0.1 **(Table 2; Supplementary Figure S1; Supplementary Tables S2.1-2.12).**

Figure 2 – Percentage of children who experienced resource allocation in past 3 months and direct care in past two weeks from their biological fathers and mothers, by child's sex. Asterisks (*) mark types of care for which logistic regression analyses showed evidence of a difference in care provision between sons and daughters (there was no evidence of a difference in care provision by child's sex from mothers). Odds Ratios for all types provided in Table 2.

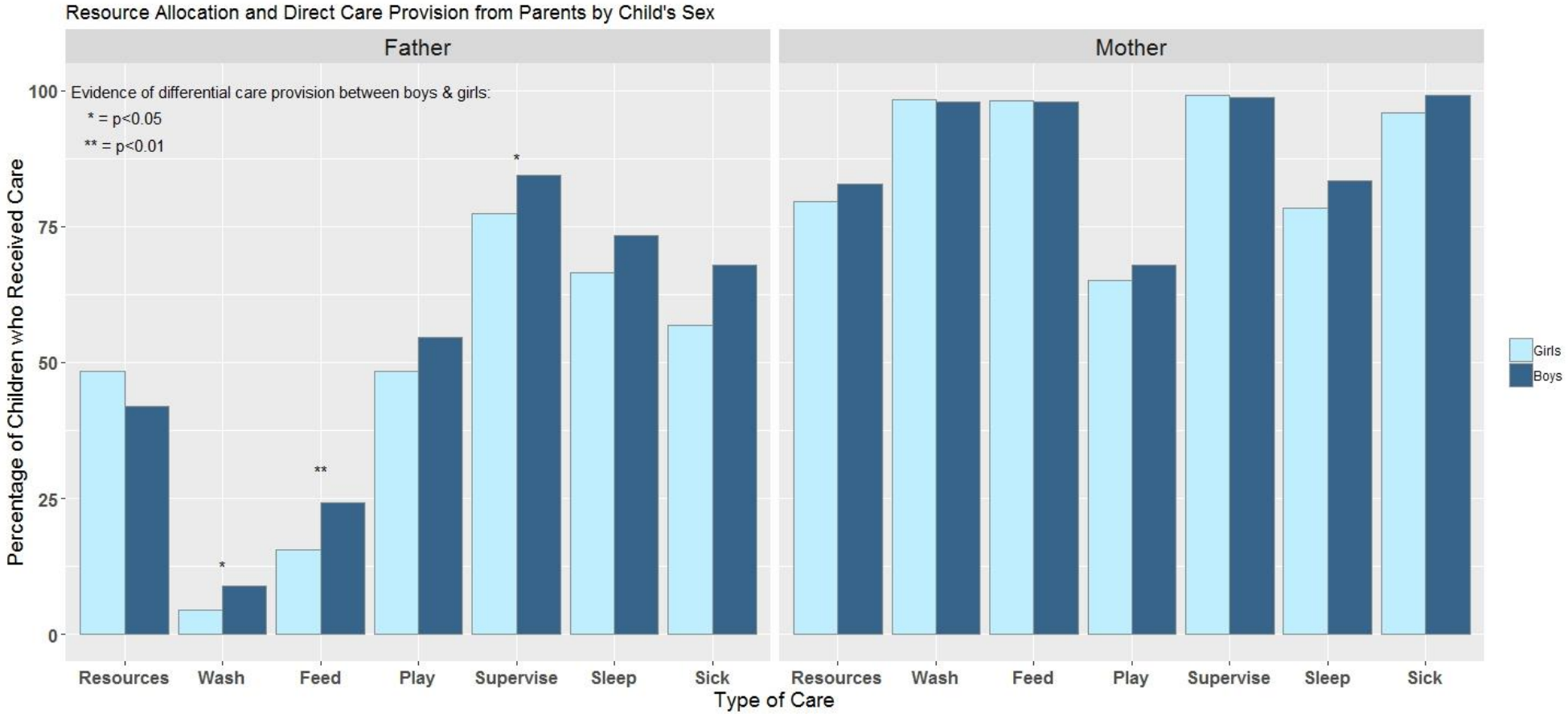


Table 2 – Logistic regression outputs showing associations between child's sex and each type of parental care provision. Effect sizes (Odds Ratios) adjusted for child's age (continuous) and age-squared. Full models for each type of care available in Supplementary Material Tables S1.1-S4.4. Resource allocation is from alive mothers (n=801) and non-resident fathers (n=239); all six forms of direct care are from co-resident parents only (Mothers: n=728; Fathers: n=547); caring for sick children is limited to children who had been sick in past two weeks (n=215).

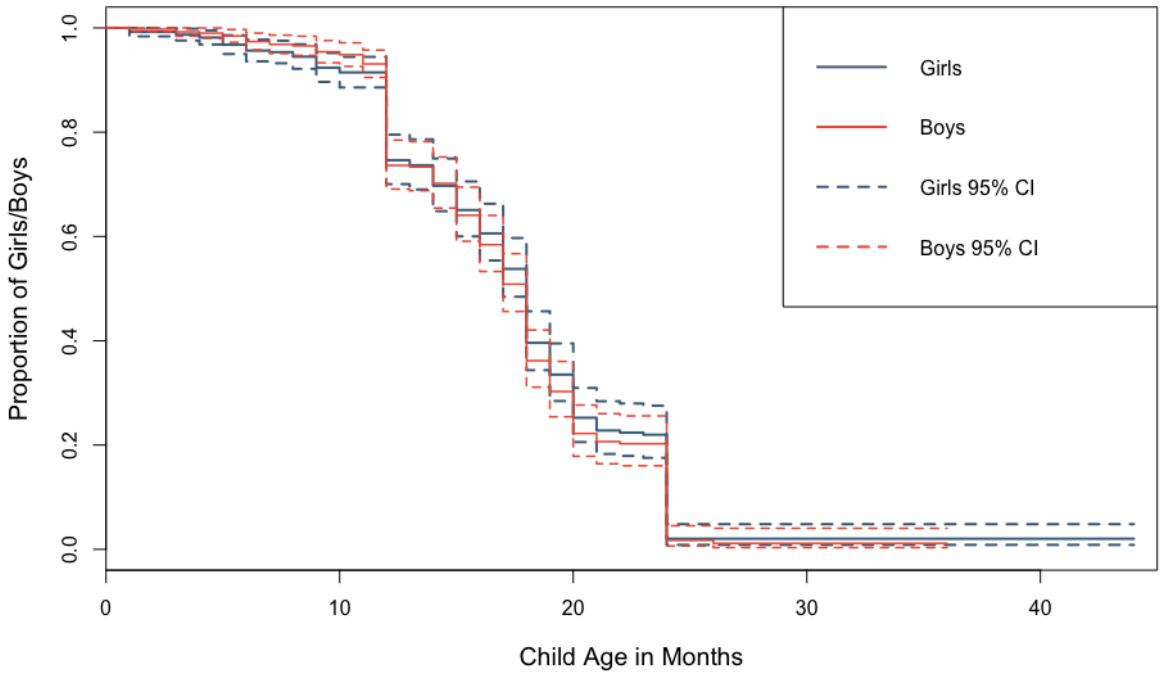
	Odds Ratio (95% CI)		Odds Ratio (95% CI)		Odds Ratio (95% CI)		Odds Ratio (95% CI)	
Type of Care	**Resource Allocation**		**Washing**		**Feeding**		**Playing**	
	Mother	Father	Mother	Father	Mother	Father	Mother	Father
n	807	239	728	547	728	547	728	547
Child is Male	1.21 (0.84-1.73)	0.86 (0.51-1.46)	0.75 (0.26-2.19)	2.19* (1.07-4.47)	0.88 (0.31-2.46)	1.76** (1.14-2.71)	1.12 (0.81-1.53)	1.24 (0.88-1.74)
Type of Care	**Supervising**		**Sleeping Next To**		**Caring if Sick**		**Exclusive Breastfeeding**	
	Mother	Father	Mother	Father	Mother	Father	Mothers	
n	728	547	727	547	204	143	541	
Child is Male	0.59 (0.14-2.48)	1.63* (1.06-2.52)	1.45~ (0.95-2.20)	1.28 (0.84-1.93)	4.30 (0.47-39.47)	1.56 (0.78-3.1)	0.85 (0.60-1.20)	
Type of Care	**Parents Married vs Divorced**		**Parents Married vs Divorced**		**Parents' Co-reside vs Live Apart**		**Parents' Co-reside vs Live Apart**	
	Full Sample		First Child Only		Full Sample		First Child Only	
n	653		101		793		166	
Child is Male	1.00 (0.65-1.55)		1.13 (0.45-2.82)		1.12 (0.83-1.51)		1.42 (0.74-2.73)	

~p<0.10; *p<0.05; **p<0.01; ***p<0.001

3.3. Breastfeeding Duration, Parental Marital Status and Co-Residence

There was almost universal coverage of breastfeeding among the children surveyed (99% of children experienced at least some breastfeeding), with 30% of children still breastfeeding during the survey period. The median time to weaning was 15 months; this did not differ by child's sex. The majority of weaned children were breastfed exclusively for at least 6 months (62%). More girls were exclusively breastfed for at least 6 months (63%) than boys (60%). Although sons had lower odds of being exclusively breastfed for six months or longer compared to daughters, there was no evidence that this difference was not due to chance **(Supplementary Table S3.1**). A Kaplan-Meier survival curve showed no visible difference between duration of overall breastfeeding between sons and daughters and a log-rank test conducted to check equality of the survivor function across both sexes confirmed this (p=0.27). Discrete-time survival analysis showed no difference in age at weaning among sons and daughters **(Figure 3; Supplementary Table S3.2; Supplementary Figure S2).** Neither parental marital status nor residential situation were related with children's sex **(Table 2; Supplementary Tables 4.1-4.4).**

Figure 3 – Kaplan Meier Survival Curves showing difference in overall breastfeeding duration between boys and girls with 95% Confidence Intervals.



3.4. Trivers-Willard Effect

We found no evidence of a Trivers-Willard effect: provision of all types of care from either parent did not differ by child's sex between food secure and food insecure households. Full models for each type of care are presented in **Supplementary Tables S5.1-5.16.**

4. Discussion

Sex biased parental care is common throughout the world with parents expected to direct investment towards the sex with a higher fitness pay off. In our rural Tanzanian context, we find that fathers favour sons in several measures of direct parental care; but mothers do not discriminate their care in any form – resource provisioning, direct care, or breast feeding

duration – based on their child's sex. We find no evidence of a Trivers-Willard Effect, using household food insecurity as a proxy for family socioeconomic status.

We explored if mothers and fathers provided care differentially to children, without making a priori predictions about whether or how sex-bias would vary between them. Previous research suggests that mothers and fathers can differ in the care given to sons and daughters. For example, patterns similar to our finding that fathers favour sons (at least in some dimensions of care) but mothers don't discriminate have been seen in both contemporary high-income populations (Harris, Furstenberg, & Marmer, 1998) and in another Tanzanian population (among Hadza hunter-gatherers (Marlowe, 2003)). Other studies document a paternal bias towards sons without reporting on maternal biases (Nettle, 2008); or report on maternal biases towards daughters without collecting data on fathers (Suitor & Pillemer, 2006). One particularly large-sample study of British families reports finds fathers spend more time engaging in childcare activities with sons while mothers favour daughters (Lawson & Mace, 2009). Analysing data from South Africa, Bangladesh, Indonesia and Ethiopia, a study finds substantial variation by country in parental investment in children's education by both child and parent's gender (Quisumbing & Maluccio, 2003). The authors highlight the need to consider context-specific factors that drive parental gender preferences. A study of parental time investment among Asian families in the US suggests that norms of son preference persist post-migration but only for mothers (Kaushal & Muchomba, 2018). Mothers spend more time with young sons than daughters whereas fathers are gender neutral with this age-group (0-5 years); as children grow older, mothers spend more time with daughters and fathers with sons (6-17 years).

What lies behind such variation in the behaviour of mothers vs. fathers in relation to child sex is not immediately obvious, but may reflect contextual differences in sex-specific costs and benefits of care and related cultural variation in gendered division of parenting.

One explanation for fathers caring more for boys than girls in the context of rural Tanzania could be that fitness interests of fathers and sons are more closely associated than those of fathers and daughters, resulting in greater investment from fathers in sons. For example, in patrilineal and patrilocal societal structures male relatives may cooperate more with each other as residential and descent patterns favour men, whereas women move away from their relatives and do not inherit either the family name or wealth (Gibson, 2008; Pashos & Mcburney, 2008). Mothers on the other hand may invest equally because they stand to receive equal returns from both sexes: as well as receiving the benefits sons are expected to bring in terms of reproductive and financial payoffs, they also benefit from the help daughters provide with housework and childcare later in life (which may have relatively little impact on fathers). It would be instructive to explore this possibility with data on the long-term consequences of parental investment in sons versus daughters.

In contrast to our finding that fathers bias some care towards sons, our previous research in this population indicates that among recent cohorts parents invest more in their daughters' education compared to their sons' (Hedges et al. 2018). This may be because, in the context of agropastoralist livelihoods boys subsistence work (farm work, cattle herding) is relatively difficult to combine with school, whereas girls' work (largely domestic tasks) can be more easily be done outside of school hours (Hedges et al., 2018). Together, these studies highlight that sex-biases in parental care can vary across the child's life course and across the dimension of care considered.

On a more proximate level, our findings are consistent with articulated gender norms relating to parental care in Kisesa. In exploratory focus group discussions with parents of children under 5-years of age (conducted alongside quantitative data collection), both mothers and fathers commented on gendered aspects of parenting. Several mothers indicated that direct physical care of daughters by fathers was taboo, with one stating "*he can help you wash and clothe the child, but it should not be a female child…it's normal for a man to wash a male child but not a female child"* and another corroborating this "*when a female child reaches two or three years old she shouldn't be washed by her father".* This sentiment was echoed by fathers, with one stating "*I think the girl child under the age of five, may be some are afraid of female gender… people here are sensitive with gender… the big percent is done by women"*. While not all parents shared these views (one parent countered that child sex was of little relevance "*the issue is not whether it is a male or a female child; he would have done the same because it is his child"),* the articulation of these norms by parents suggest that our quantitative findings regarding discriminatory paternal care reflect real behaviour.

The lack of evidence for a Trivers-Willard effect on parental care in this population is perhaps not surprising. Previous literature has not reached a consensus on whether post-natal parental care is predicted to follow a Trivers-Willard pattern (Keller et al., 2001; Veller et al., 2016). Confusion is introduced because the comparative fitness value of having a son versus a daughter can vary independently of the marginal fitness returns of investing in current children of either sex. According to the TWH, a resource-poor mother would benefit from biasing the sex ratio of her children towards daughters rather than sons; yet, in the event that the mother has already given birth to both a son and a daughter, each additional

unit of post-natal investment is likely to have a more substantial effect on male reproductive success – given the typically greater variability in male reproductive success – and thus she should direct this investment to the son. So, if sons do accrue more benefits than daughters from each unit increase in investment, then post-natal biases towards boys are expected regardless of parental wealth (Keller et al., 2001). This argument is further convoluted due to the blurred line between biases in sex-ratio at birth and post-natal care e.g. infanticide or 'passive neglect' can be a means of adjusting the sex ratio of one's family postnatally.

Limitations and Future Work

It is possible that the extra care sons receive from fathers is surplus and will not impact their survival and eventual reproductive success. If this is the case then a functional/adaptationist perspective on sex-biased parental investment may be misguided. However, the under-5 year age group is a critical period for children and we would expect that even marginal amounts of care could have a potentially significant impact on their wellbeing. Thus, a logical follow-up to this study would be to investigate a link between parental care and children's health and survival. It is also possible that although boys receive extra care from their fathers, girls may receive such care but from other family members so that they are not suffering from an overall deficit of care. Further research exploring care for children by other kin could explore this possibility.

Conclusion

We report novel evidence of sex-biased parental care in early childhood among a Sukuma community in north-western Tanzania. We also add to previous scholarship by providing

detailed information on what both fathers and mothers do for their young children in this context. We find that mothers provide more direct care to children, but also observe significant amounts of direct care and resource provisioning from fathers. Furthermore, we find that fathers provide direct care differentially by child's sex while mothers do not discriminate. Sex-biases in fathering appear limited to direct interactive forms of childcare, and are further reflected in local gender norms articulated by parents. An evolutionary perspective predicts that these patterns are ultimately accounted for by higher returns to paternal care in sons over daughters, as has been suggested in past research in other cultural settings (e.g. (Nettle, 2008)). Further research will be required to determine whether or not these patterns are generalizable to related low-income settings, and whether sons actually benefit from more care from their fathers during this vulnerable stage of child development.

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Author Contributions

All authors contributed to study design, AH, DWL, SS, MU collected the data, AH analysed data, AH, DWL, SS, RS wrote the paper.

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Publishing Ethics

The manuscript is the authors' own original work and does not duplicate any other previously published work. It has been submitted only to Evolutionary Human Sciences, and is not under consideration, accepted for publication or in press elsewhere. All listed authors know of and agree to the manuscript being submitted to Evolutionary Human Sciences. The manuscript contains no abusive, defamatory, fraudulent, illegal, libellous or obscene content.

Conflict of Interest

None.

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