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Children are important too: juvenile playgroups and maternal childcare in a foraging population

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Author-supplied statements

Relevant information will appear here if provided.

Ethics

Does your article include research that required ethical approval or permits?:
Yes

Statement (if applicable):
This research was approved by UCL Ethics Committee (UCL Ethics code 3086/003) and carried out with permission from local government and Agta leaders. Informed consent was obtained from all participants after group and individual consultation, with explanation of the research objectives in the indigenous language. A small compensation (usually a thermal bottle or cooking utensils) was given to each household.

Data

It is a condition of publication that data, code and materials supporting your paper are made publicly available. Does your paper present new data?:
Yes

Statement (if applicable):
The datasets and analysis script supporting this article have been uploaded as part of the supplementary material. As the Agta are a small and vulnerable population and the data of a personal nature every effort has been made to anonymise this data and all personal information has been removed.

Conflict of interest

I/We declare we have no competing interests

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Authors' contributions

This paper has multiple authors and our individual contributions were as below

Statement (if applicable):
AEP conceptualised this study, designed the field methodology, and conducted focal follows with SV. AEP conducted data processing and analysis, while the analysis process was continually reviewed by EE, MD and DS. AEP drafted and refined the manuscript which was critically revised with by EE. MD, DS, NC, SV and ABM helped draft the manuscript. ABM oversaw and ran the project.

Submitted to Phil. Trans. R. Soc. B - Issue

Page 2 of 27

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1 **Children are important too: juvenile playgroups and maternal childcare in a**
2 **foraging population, the Agta**

3

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12

13 **Abstract**

14

15 Non-maternal caregivers (allomothers) are hypothesised to lighten the mother's workload,

16 allowing for the specialised human life history including relatively short interbirth intervals and

17 multiple dependent offspring. Here, using in-depth observational data on childcare provided to

18 78 Agta children (a foraging population in northern Philippines; aged 0-6 years), we explore

19 whether allomaternal childcare substitutes and decreases maternal childcare. We found that

20 allomother caregiving was associated with reduced maternal childcare, but the substitutive

21 effect varied depending on the source and type of care. Children-only playgroups consistently

22 predicted a decrease in maternal childcare. While grandmothers were rarely available, their

23 presence was negatively associated with maternal presence and childcare, and grandmothers

24 performed similar childcare activities to mothers. These results underscore the importance of

25 allomothering in reducing maternal childcare in the Agta. Our findings suggest that flexibility in

26 childcare sources, including children-only playgroups, may have been the key to human life

27 history evolution. Overall, our results reinforce the necessity of a broad conceptualisation of

28 social support in human childcare.

29

30 **Keywords**

31 Childcare; playgroups; grandmothers; allomothering; support; hunter-gatherers

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36 Primates, compared to other mammals, are known for their "slow" life history; taking a longer

37 time to reach maturity, having relatively fewer dependent offspring and longer interbirth

38 intervals [1]. As primates, humans clearly share some of these characteristics. However, we are

39 unusual in our ability to "speed-up" reproduction [2]. Humans, compared to other great apes

40 wean infants relatively early, meaning mothers are physically able to resume reproduction

41 quicker, leading to shorter interbirth intervals with multiple highly dependent offspring [3].

42 Compared to other primates, humans produce and invest in a larger number of highly costly

43 offspring. It has been theorised that such "stacking" of offspring is only possible due to high levels

44 of allomothering, which is unseen in other great apes [3].

45

46 Allomothering refers to investments of time and/or energy in childrearing from any individual

47 who is not the child's mother. These transfers of time/energy can include childcare, such as

48 holding or playing with a child (i.e., direct caregiving/care; the focus of this paper), as well as

49 provisioning food and other resources (i.e., indirect caregiving/provisioning)[4]. To date,

50 evolutionary anthropology's approach to understanding allomothering has largely (but not

51 exclusively) investigated the ultimate explanations of allomothering (i.e., why it evolved) by

52 examining allomother effects on maternal reproductive success (measured by fertility, child

53 health and/or development and child survival)[5,6]. From this perspective, allomothers are

54 assumed to reduce maternal energetic burden, freeing up the mother, allowing her to "stack"

55 offspring[3]. Humans arguably evolved an obligate system of cooperative childrearing (also

56 referred to as cooperative breeding *sensu lato*) in which allomothers facilitate the more rapid

57 production of children *and* offspring survival[5,7,8].

58

59 For a holistic understanding of cooperative childrearing, however, ultimate reasons must be

60 complemented with an understanding of *how* allomothering translates to increased reproductive

61 success[6,9]. Conceptually, this is dependent on how mothers reinvest time/energy "freed up"

62 by allomothering. For example, mothers could reallocate their "freed up" time/energy back into

63 the existing child by, for instance, playing with the child at the same time as an allomother [10].

64 This is expected where mothers opt to increase child quality, as children then receive higher

65 levels of care overall, leading to better outcomes, as demonstrated in a range of studies [11,12].

66 Alternatively, mothers may reduce childcare and provisioning, and re-invest elsewhere (known

67 as *substitutive* investments[8]). In this case, allomaternal help may be associated with increased

Submitted to Phil. Trans. R. Soc. B - Issue

Page 4 of 27

68 fertility rather than child quality, as 'saved' energy is re-invested into reproductive effort.

69 Therefore, the 'ultimate' outcome of allomothering depends on the mechanism: child condition

70 and survivorship may even be *reduced* in some instances due to increasing fertility rates [8]- yet

71 these pathways are frequently overlooked (but see [13,14] for notable exceptions).

72

73 This paper focuses on the mechanism behind how allomaternal caregiving influence maternal

74 and child outcomes. We ask whether allomaternal childcare (i.e., not provisioning) substitutes

75 maternal childcare, and whether this is influenced by the type of allomother. By substitution, we

76 mean whether *any form of childcare* by an allomother which is associated with reductions in *any*

77 *form of childcare* by the mother. By exploring these mechanisms, we are better able to

78 hypothesise about the mechanism behind the evolution of cooperative childrearing and gain

79 insights into human life history.

80

81 *Who helps?*

82 There is a wealth of literature on cooperative childrearing in small-scale societies, especially

83 hunter-gatherers, exploring its consequences for maternal and child outcomes. Hunter-gatherers

84 are populations which rely heavily (but not necessarily exclusively) on hunted, fished or foraged

85 resources. These groups tend to be highly cooperative, widely sharing resources and labour [15].

86 Mothers in small-scale societies provide a high proportion of childcare [16,17], due to on-demand

87 breastfeeding and close physical contact to mitigate early mortality risks [11,12]. As children age

88 and become more independent maternal childcare decreases [11,16,18,19], suggesting that after

89 weaning the opportunity for allomaternal care increases.

90

91 Some of the earliest research explored paternal care (a form of allomaternal care), hypothesising

92 that male provisioning allowed mothers to redirect their energy from production activities to

93 fertility and childcare, increasing maternal reproduction and child survivorship [20,21]. For

94 instance, among Agta foragers, males generally provide the majority of calories, while females

95 spend more time in domestic tasks and childcare [22]. While male childcare is high in some

96 populations (e.g. the Aka [23]), fathers typically specialise in provisioning [18], and as such,

97 studies have found that father absence is associated with greater child mortality in a range of

98 pre-industrial societies [24]. However, this does not seem to be universal: only 47% of statistically

99 controlled studies (n = 15) reviewed by Sear and Mace [12] found a positive relationship between

100   father presence and child survival, which may be because contributions from fathers can be

101   replaced by other allomothers [11].

102

103   Beyond fathers, studies have investigated grandmothers as key allomothers given their close

104   genetic relationship with grandchildren and reduced caring responsibilities[25]. In support, Sear

105   and Mace [12] found that maternal grandmother presence was most consistently positively

106   correlated with child survival (64% of 11 statistically controlled studies in natural fertility

107   populations). However, a number of studies, particularly in hunter-gatherer/subsistence farming

108   populations, have indicated that grandmothers have little allomaternal involvement, both in

109   terms of direct childcare [18,26] and provisioning [27]. For example, among Aché foragers, only

110   ~10% of females in their 30s co-resided with their mothers [27]. For most mothers, grandmothers

111   were not available as allomothers.

112

113   Overall, fathers and grandmothers are sometimes, but not always, available as important

114   allomothers. Interestingly, there is increasing cross-cultural evidence that children become

115   'helpful' in terms of household tasks, food production and childcare after 6-7 years of age

116   [3,28,29]. Demographic studies highlight considerable levels of juvenile contributions [30,31],

117   particularly in high-fertility societies with large siblings cohorts and few educational

118   commitments [32]. Children provide significant help to their siblings and mothers, ensuring

119   positive energy balances, and ultimately, household survival [26,33,34]. As a result, we expect

120   siblings to be important allomothers in high-fertility populations.

121

122   It is important to note that, under cooperative childrearing, mothers are not restricted to receive

123   help from kin, but may receive help from *anyone* [35]. In fact, the best cooperative strategy for

124   successful reproduction is likely to be a flexible one, depending on which allomothers are

125   present, willing and able [5,32]. Meehan, Helfrecht and Malcom [36] indicate that mothers and

126   children's social networks are composed of a wide range of individuals and households are rarely

127   dependent on a single type of allomother. Evidence suggests that non-relatives gain direct

128   benefits from allomaternal childcare, such as having someone available to help your own children

129   in return [37] or learning key parenting skills to improve child survival [38]. Indeed, several studies

130   have indirectly shown that a considerable amount of allomaternal caregiving is provided by non-

131   relatives [11,18,27].

Submitted to Phil. Trans. R. Soc. B - Issue

Page 6 of 27

132 A common feature of social life across hunter-gatherer societies is the formation of mixed-age

133 mixed-sex playgroups, where children and young teens from different households play. The

134 literature on playgroups in hunter-gatherers is extensive, with surprisingly similar descriptions of

135 children collectively roaming, with freedom, around the camp and the surrounding areas [19,39–

136 41]. These playgroups comprise of children aged ≥2 years, often without adult supervision [40].

137 Studies have often focused on the function of play behaviours from a developmental perspective

138 [42]. However, playgroups also provide protection, care, teaching and stimulation to younger

139 children [17,39]. Despite this, playgroups have not been empirically explored as a form of

140 childcare in the cooperative childrearing literature. If playgroups allow mothers to reduce their

141 caregiving, then playgroups may be an important facilitator for multiple, overlapping dependant

142 offspring.

143

144 *Current Aims*

145 This paper aims to move beyond the focus on kin as allomothers and explores allomaternal care

146 from the entirety of a child's social network. In doing so, it offers important insights into the

147 dynamics of cooperative childrearing in humans. In particular, we investigate whether direct

148 caregiving by non-kin, juvenile playgroups, as well as relatives (fathers, siblings, grandparents,

149 aunts and uncles and cousins) reduces maternal childcare in a hunter-gatherer population, the

150 Agta. Using in-depth observations of 78 children, we test the degree to which all allomaternal

151 childcare is substitutive of maternal childcare, implicitly allowing her to re-invest energy into

152 other domains. Once the overall substitutive role of allomaternal care is established, we then

153 compare the importance of fathers, siblings, grandparents, distant and non-kin as well as

154 playgroups.

155

156 As observed in other hunter-gatherer societies, we hypothesise that childcare is provided by a

157 wide range of individuals among the Agta, but that siblings and non-related juveniles in

158 playgroups will be particularly important caregivers. In contrast, we expect fathers to have a small

159 role in caregiving given their focus on food production [22]. Further, we hypothesise that the

160 effect of grandmothers will be limited due to their high mortality and high residential mobility

161 within the population (meaning grandmothers are likely to live elsewhere) [43,44]. Specifically,

162 we predict that: 1) allomaternal childcare from fathers and grandmothers will have no

163 relationship with maternal childcare; 2) childcare from individual siblings will have a negative

Page 7 of 27

Submitted to Phil. Trans. R. Soc. B - Issue

164 relationship with maternal childcare, indicating substitution; and 3) allomaternal care from

165 playgroups (including siblings, distant and non-kin juveniles) will be negatively associated with

166 maternal childcare, also indicating substitution.

167

168 **Methods**

169

170 The Agta

171 There are around 1,000 Agta living in the Palanan municipality of north-eastern Luzon,

172 Philippines. Riverine and marine spearfishing provides their primary source of animal protein,

173 supplemented by hunting and gathering, as well as low-intensity cultivation, wage labour and

174 trade [22,45]. The Agta are bilocal [46], meaning children are equally likely to reside with either

175 their mother's or father's family [47]. As the Agta frequently change residential camp, children

176 will likely spend time with a wide range of kin and non-kin over the course of their childhood.

177 Previous research has highlighted their extensive cooperation, between kin and non-kin, in the

178 domains of food sharing and childcare [37,47–49]. The Agta practice serial monogamy and have

179 a total fertility rate of 7.7 [43] and a short average interbirth interval of 2.8 years. Infant and

180 childhood mortality rates are high, with an estimated 38.9% of offspring dying before the age of

181 16 years [43]. Mortality is higher for males throughout childhood and early adulthood; however,

182 the high costs of reproduction mean that females are increasingly underrepresented in older

183 cohorts [44].

184

185 The Agta style of childcare, like most other hunter-gatherers, has been labelled as indulgent,

186 affectionate and intensive where infants are permanently held, cuddled or played-with [16,45].

187 Children are breastfed on-demand for approximately two years (as observed during our fieldwork

188 and reported approximately by mothers). Young children aged 0-2 years are frequently carried

189 by mothers, usually in fabric slings [50]. As children are weaned they are carried less frequently,

190 watched less intensively, and have significant freedom within camp as they start to participate in

191 mixed-age, mixed-sex playgroups [16,45,51]. As documented in other populations [3,28,29],

192 while younger children spend the time as they like, children after the age of six become

193 increasingly involved in the household economy and provide childcare to younger siblings

194 [16,45,50].

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Submitted to Phil. Trans. R. Soc. B - Issue

Page 8 of 27

196   Data collection

197   Data collection occurred over two field seasons from April-June 2013 and February-October

198   2014. In the first season we censused 915 Agta individuals (54.7% which were male) across 20

199   camps. Following relative aging protocols [52], accurate ages were established for all individuals

200   post data collection. Relatedness was established from household genealogies (involving both

201   mothers and fathers; see [44,47]). In the second season we stayed approximately 10-14 days in

202   ten camps to conduct focal follows of children.

203

204   Focal follows were conducted with 78 children across 10 study camps: 34 children aged 0-1.9 and

205   44 children aged 2 – 5.9. These two age groupings we made based on the observation that

206   children are still intensively breastfed up until the age of two, while we considered children over

207   the age of 6 to be providing more allomaternal care than he/she received (a decision we made

208   during our fieldwork, prior to any analyses). No formal sampling techniques were used due to the

209   small population size, as we were able to observe the majority of children within the study camps

210   (Table S1). Where we were unable to observe all children in a camp, we observed at least one

211   child per household. Although our total sample contains more boys than girls (48 males, 61.54%),

212   this is in line with the male-biased sex ratio seen in the 0-5 year cohort in this population[44].

213

214   Recording allomothering

215   Two researchers (A.E.P and S.V), observed a focal child for a 9-hour period (see [13] for protocol).

216   These observations were broken into 3x 4-hour intervals (6:00 – 10:00, 10:00 – 14:00 and 14:00

217   – 18:00) with a 15-minute break at each hour, and each 4-hr observation was conducted on non-

218   consecutive days to reduce any sampling bias. During observation, researchers recorded the

219   activities of the focal child every 20 seconds, including who came within 3m of the focal child,

220   and the nature of their interaction.

221

222   Information on mothers was recorded regardless of the 3m proximity to the focal child. Where

223   observable (common due to the open nature of camps), activities of the mother were recorded

224   (which included: providing high-investment childcare for the focal child such as carrying/holding,

225   playing; engaging in childcare of another child; household tasks; leisure; being present but not

226   actively engaging in a task and; food production). If the mother was absent, but the observer

227   knew the maternal activity based on reports from family members or neighbours (i.e. individual

228   x has gone to collect water), then this activity was recorded for the mother until she returned.

229   Otherwise, if the mother was absent, she was recorded as 'not present'.

230

231   For allomothers, their presence and information on their activities were recorded if they were

232   within three meters of the focal child. During data collection, only individuals estimated to be 6

233   years+ were recorded as allomothers. Once accurate ages had been produced, records of

234   'allomothers' aged below 6 years were removed from the analysis. If a focal child was involved in

235   a playgroup (defined as when three or more children (adults could also be involved) engaged

236   collectively in a play activity or roamed around the camp [39]) then the observer recorded the

237   playgroup as a binary event (yes or no), for each of the individuals involved in the playgroup,

238   during each observation interval.

239

240   Prior to the main data collection, both researchers piloted the methodology and were in close

241   agreement about childcare/activity categories. In the following analyses, childcare by mothers

242   and allomothers has been categorised into low-investment childcare (passive engagement; being

243   within three-meter proximity and watching a child) or high-investment childcare

244   (carrying/holding, playing, grooming, cleaning or providing medical attention,

245   feeding/breastfeeding, teaching or otherwise stimulating a child; see Table S2). Throughout this

246   paper, *childcare* refers to both low- and high-investment activities, unless otherwise specified.

247

248   Data analysis

249   *Chi-squared analysis*

250   To test whether allomaternal childcare was substitutive overall, we explored whether maternal

251   activity budgets were correlated with allomaternal caregiving (regardless of type or source). Chi-

252   squared proportion tests compared the proportion of time allocated to different tasks between

253   1) mothers looking after a child alone, and 2) mothers with allomaternal help.

254

255   *Logistic multilevel models*

256   The association between allomothers and maternal childcare according to the type of allomother

257   was explored with multilevel logistic regression models, with two outcomes. The first outcome

Submitted to Phil. Trans. R. Soc. B - Issue

Page 10 of 27

258 was *maternal absence*, coded as 1 for presence and 0 for absence at the point of observation. If

259 a mother is absent, she is not providing childcare to the focal child, thus the allocare is

260 substitutive. The second outcome was *intensity of maternal childcare* (contingent on their

261 presence), coded as 1 if mothers were engaged in active or high-investment childcare or 0 if they

262 were engaged in passive or low-investment childcare. This second outcome explores partially

263 substitutive allocare, where mothers are present (potentially supervising) but can engage in

264 other activities.

265

266 The unit of analysis was each individual instance of childcare between an allomother and the

267 focal child, resulting in a total observational sample size of 202,351 observations from 78 children

268 in 84,240 observational intervals (removing those intervals in which children were alone or only

269 with their mother). To account for the temporal sequencing in the data (i.e. that the first

270 observation will likely predict the second, and third observations etc. with decreasing likelihood

271 over time) the time of the observation is included as a fixed effect to adjust for the non-

272 independence [53]. For children aged 0-1.9 years (n=34 children from 33 households), there were

273 82,322 dyadic interactions between 622 dyads, involving 301 allomothers from 94 households.

274 For children aged >2 years (n=44 children from 36 households), there were 120,029 dyadic

275 interactions between 901 dyads, involving 335 allomothers from 95 households.

276

277 Logistic mixed effect models were carried out in R v 3.2.2 using package Lme4 (function glmer

278 [54]). To take account of clustering, random effects were added at the dyadic level (since each

279 dyad had multiple interactions), the allomother level, the allomother's household, the child's

280 household, and at camp level. Originally, we intended to add the child as a random effect.

281 However, since the majority (88.46%) of households only contributed one child to the sample,

282 we encountered convergence issues. The random effect variance attributed the child level was

283 nil, thus its removal had no impact on the model.

284

285 The main predictor of kin type was modelled as 10 binary dummy variables (0 = no, 1 = yes).

286 Individuals were established as either a: father, brother, sister, maternal grandmother, paternal

287 grandmother, maternal grandfather, paternal grandfather, extended kin (r = 0.25, but excluding

288 grandparents as named above), distant kin (r ≥ 0.03125 & r < 0.25) and non-kin (r < 0.0325).

289 Therefore, a sister would be recorded as 0 for the father, brother, maternal grandmother,

Page 11 of 27

Submitted to Phil. Trans. R. Soc. B - Issue

290 paternal grandmother, paternal grandfather, maternal grandfather, extended, distant and non-

291 kin variables and 1 for the sister variable.

292

293 As playgroups were hypothesised to be of importance (in and of themselves, as well as altering

294 the effect of specific allomothers within playgroups) an additional set of models were run. These

295 models include a predictor term for playgroup (0 = allomother not in a playgroup, 1 = allomother

296 in a playgroup), as well as interactions for the different types of participants in playgroups

297 (sisters, brothers, distant, extended and non-kin, defined based on descriptive analysis of the

298 composition of playgroups). These interactions test whether the substitutive effect of care from

299 a particular allomother was altered by being in a playgroup. Due to the lack of playgroups in the

300 0-1.9 sample, the playgroup analysis was only run in the 2-5.9 sample.

301

302 All models contained controls for child age in years (as children receive less care from their

303 mother as they age) and sex (0 = male). The distant kin, extended kin and non-kin models

304 controlled for the allomother's age and sex. Beyond what is presented below, all model outputs

305 are presented in the SI Tables 7-62 for transparency, and results in text are given alongside 95%

306 confidence intervals of the odds ratios (OR). Multiple comparisons were adjusted for using

307 Hochberg correction, and adjusted p-values are given in Table S5.

308

309 *Post-hoc analyses*

310 We conducted post-hoc exploratory analyses on the type of care provided by the three

311 allomother types who were negatively associated with maternal childcare. This post-hoc analysis

312 sought to test whether different allomothers engaged in different types of childcare. Looking at

313 the mean proportion of interactions grandmothers (n= 19), grandfathers (n=18) and playgroups

314 (n=190) spent in either: a) proximity/watching; b) playing; c) caring for; and d) holding a child,

315 permutation tests were run to explore if the means significantly differed between the groups;

316 100,000 simulations shuffled the existing data randomly to produce 100,000 simulated mean

317 differences. The p-value is then produced based on the number of times out of 100,000 that the

318 simulated mean difference was either higher or lower than (or equal to) the mean difference of

319 the actual sample.

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Submitted to Phil. Trans. R. Soc. B - Issue

Page 12 of 27

321 **Results**

322

323 Descriptive statistics

324

325 *Who cares?*

326 Across the 78 children, 75 received childcare from their mothers (96%), 69 from fathers (88%),

327 22 and 8 from their maternal and paternal grandmothers, respectively (28% and 10%), and 23

328 and 13 from their maternal and paternal grandfathers, respectively (29% and 17%, Table S3). In

329 total, children interacted with 75 sisters (per child: mean = 0.962, SD = 1.167) and 75 brothers

330 (per child: mean = 0.915, SD = 1.200), as well as 366 distant kin (per child: mean = 4.690, SD =

331 3.447), 173 extended kin (per child: mean = 2.218, SD = 2.049) and 703 non-kin (per child: mean

332 = 8.949, SD = 5.748).

333

334 Figure 1 outlines the patterns of childcare children received from mothers and allomothers (See

335 Figures S1 and S2 for the caregiver's perspective). For children aged 0-1.9 years, mothers

336 provided the majority of childcare (25.9% of all caregiver-child interactions), followed by non-kin,

337 distant kin and extended kin. Siblings and fathers were involved in 7.23-8.4% of caregiver-child

338 interactions, and grandparents in 0.3-3%. For children aged 2-5.9 years, non-kin (23.81%) rather

339 than mothers (18.98%) provided the most childcare. Fathers, brothers and sisters had higher

340 levels of childcare involvement (ranging from 7.7-12.8%). Maternal grandparents (1-1.9%) as well

341 as other extended family members were less involved in childcare. Paternal grandparents'

342 involvement was notably low at 0.3-0.6%.

343

344 *Grandmothers' availability and participation*

345

346 Averaged across the population, grandmothers provided little childcare because they were

347 frequently not present (Figure S3). Only 43 (55.13%) and 34 (43.59%) of children had a maternal

348 and paternal grandmother alive, respectively. Across 78 children, 25 co-resided (in the same

349 camp) with a maternal grandmother (32.05% of all children; 58.14% of children with maternal

350 grandmothers alive), and 11 with paternal grandmothers (14.10% of all children; 32.35% of

351 children with paternal grandmothers alive). Overall, only 22 (28.21%) and 8 (10.26%) children

352 ever received low-investment care from their maternal or paternal grandmother, respectively.

353 For grandmothers who co-resided with focal children, 88.0% of maternal grandmothers and

354 72.73% of paternal grandmothers were ever observed to provide low-investment childcare. A

Page 13 of 27

Submitted to Phil. Trans. R. Soc. B - Issue

355   comparable result was found for high-investment activities (17 children received high-

356   investment care from maternal grandmothers, equating to 21.8% of all children, or 68% with

357   maternal grandmothers co-residing; 7 children received high-investment care from paternal

358   grandmothers, equating to 8.97% of all children, or 63.64% with paternal grandmothers co-

359   resident). While maternal grandmothers were more likely to be alive, present and provide

360   childcare compared to paternal grandmothers (Table S4), our results indicate that, overall, both

361   grandmother types were frequently *not* present in camp, and when they were, they did not

362   necessarily provided care to grandchildren.

363

364   *Playgroups*

365   In playgroups, the average age of the focal children was 3.94 (SD = 1.28), while the average age

366   of the allomothers was 9.85 (SD = 5.16). Only 1.8% of total observations in the 0-1.9 age group

367   were in playgroups (which occurs mainly from children aged 1.5 – 2 years), while a total of 12.9%

368   (observations n = 19,130) of the 2-5.9 sample's observations were in playgroups. The majority of

369   focal children's interactions in playgroups were with children aged 6-11 years (n = 16,548, 78.3%),

370   while interactions with adolescents aged 11-16 years comprised of 17.3% (n = 3,655) followed by

371   interactions with individuals aged 16 + years (n = 934, 4.3%). The majority of individuals in the

372   playgroup came from kin categories with a higher proportion of juveniles: sisters (23.5%);

373   brothers (14.22%); distant kin (25.35%); extended kin (4.34%) and non-kin (31.49%). Adults had

374   very little, if any, involvement in playgroups: collectively, parents and grandparents consisted of

375   less than 1% of playgroup members. To summarise, this suggests that playgroups can be

376   considered as *en masse* play/childcare for children aged 2-6 years by children aged 6-11 years,

377   with some lesser involvement of adolescents, without direct adult supervision.

378

379   Chi-square results

380   Mothers whose children received allomaternal care, compared to mothers looking after children

381   alone, spent 15.14 percentage points (χ^2 = 240.3, p < 0.001, 95% CI [13.37, 16.90]) less time

382   providing childcare in the 0-1.9 sample, and 61.11 percentage points in the 2-5.9 sample (χ^2 =

383   1493.4, p < 0.001, 95% CI [58.19, 63.94]). Instead, mothers receiving allomaternal care spent

384   significantly more time in food production, childcare of other children, leisure time and in

385   domestic tasks (SI Tables S6A and S6B). Therefore, overall allomaternal care was substitutive

386   rather than additive in the Agta.

387

388   Logistic multilevel models results

389   *Model set A: predicting mother presence*

390   In the following models, an odds ratio (OR) above 1 represents an increase in maternal childcare,

391   while an OR under 1 reflects a decrease in maternal childcare (Table 1 and 2, also see Figure S4A

392   and S5A). In the 0-1.9 years sample, child age was negatively correlated with maternal presence

393   (OR = 0.027, 95% CI [0.004, 0.1837], p < 0.001); a trend which was less strong in the 2-5.9 cohort

394   OR = 0.562, 95% CI [0.413, 0.7651], p < 0.001). Overall, fathers did not provide substitutive care

395   for mothers. In contrast, care from grandmothers and playgroups were associated with a

396   decreased likelihood of maternal presence. For children 0-1.9yrs, childcare by paternal

397   grandmothers was negatively associated with maternal presence (OR = 0.011, 95% CI [0.0002,

398   0.598], p = 0.027). Note, the 95% CI is wide due to the small number of paternal grandmothers,

399   thus the point estimates may be unreliable. For children 2-5.9yrs, maternal presence was

400   negatively predicted by maternal grandmothers (OR = 0.105, 95% CI [0.023, 0.471], p = 0.003)

401   and playgroup participation (OR = 0.154, 95% CI [0.145, 0.164], p < 0.001). While other

402   allomothers were not independently associated with maternal presence, this association

403   changed when the allomothers were part of a playgroup: brothers *within playgroups* were

404   associated with a lower odds of maternal presence (OR = 0.120, 95% CI [0.104, 0.138], p < 0.001),

405   as were sisters (OR = 0.125, 95% CI [0.119, 0.140], p < 0.001), extended kin (OR = 0.198, 95% CI

406   [0.158, 0.247], p < 0.001), distant kin (OR = 0.264, 95% CI [0.232, 0.301], p < 0.001) and non-kin

407   (OR = 0.140, 95% CI [0.124, 0.159], p < 0.001) (Interaction models; Table 2). Therefore, within

408   playgroups, all previously non-substitutive kin categories were negatively correlated with

409   maternal presence.

410

411   *Model set B: predicting maternal high-investment childcare*

412   As with the maternal presence models, child age was negatively correlated with maternal

413   childcare (0-1.9 years OR = 0.470, 95% CI [0.230, 0.962], p = 0.039; 2-5.9 years OR = 0.282, 95%

414   CI [0.215, 0.371], p < 0.001). Overall, grandmothers did not predict a reduction in maternal

415   childcare in either age group, nor did fathers (Table 1 and 2, also see Figure S4B & S5B). As before,

416   in the 2-5.9yrs age group, individuals *within playgroups* were significantly associated with

417 reduced likelihoods of maternal childcare. Brothers in playgroups were associated with a lower

418 odds of maternal childcare (OR = 0.118, 95% CI [0.070, 0.201], p < 0.001), as were sisters (OR =

419 0.532, 95% CI [0.361, 0.784], p < 0.001), extended kin (OR = 0.113, 95% CI [0.044, 0.284], p <

420 0.001), distant kin (OR = 0.492, 95% CI [0.342, 0.709], p < 0.001) and non-kin (OR = 0.457, 95% CI

421 [0.317, 0.657], p < 0.001)(Interaction models; Table 2). Furthermore, in the over-twos, paternal

422 grandfather care was associated with a reduction of maternal childcare when mothers were

423 present (OR = 0.073, 95% CI [0.010, 0.522], p = 0.009). The opposite is true of non-kin allomothers

424 in the under-twos (OR = 1.616, 95% CI [1.158, 2.253], p = 0.005) suggesting that mothers did not

425 allow non-kin to provide solo-childcare to younger children.

426

427 Post-hoc analyses

428

429 From the above analysis, three categories of alloparents were negatively associated with

430 maternal childcare: grandmothers, grandfathers and playgroups. Further explorative

431 permutation tests demonstrated different patterns of childcare (Figure 2; see Table S6A and S6B).

432 Grandmothers, compared to individuals in playgroups, held children more (0.113 vs. 0.019, p =

433 0.002), suggesting a pattern of care similar to mothers (Figure 2C and D). Unsurprisingly,

434 individuals in playgroups played with children significantly more than grandmothers (0.172 vs.

435 0.014, p < 0.001) and grandfathers (0.172 vs. 0.023, p = 0.001). In contrast, the only activity

436 grandfathers did more of was low-investment proximity/watching, compared to playgroups

437 (0.922 vs. 0.948, p < 0.001) and grandmothers (0.867 vs. 0.948, p = 0.044). Thus, grandfathers

438 provided extremely little 'intensive' childcare compared to all other categories.

439

440 **Discussion**

441 In the Agta, a large number of individuals were involved in providing childcare, coming from a

442 range of kin and age categories. Overall, allomaternal childcare was associated with a reduction

443 in maternal childcare. These results demonstrate that mothers who received help spent less time

444 caring for that particular child and more time in other activities, such as economic tasks, caring

445 for other children and leisure time. Thus, allomaternal care in the Agta can be considered

446 substitutive rather than additive. While we have yet to explore why care is substitutive, such

447 trends are likely influenced by ecological context, dependent on which strategies have the

448 highest fitness payoffs [8]. For instance, allomaternal care in the Agta *may* be substitutive since

449   mothers, in general, appeared to invest in high fertility due to ecological risks [43,44] limiting the

450   fitness payoff of the increased childcare associated with additive care. Further investigation

451   should explore the relationship between allomothering, environmental pressures, activity

452   budgets and fertility trends. The source of the childcare is important to consider since different

453   allomothers were associated with different effects on maternal childcare, and childcare from

454   grandmothers and playgroups appeared to be most consistently associated with reductions in

455   maternal childcare.

456

457   Absent, but helpful, grandmothers

458   Much attention has been paid to grandmothers as important allomothers[55]. In terms of

459   inclusive fitness, grandmothers arguably have much to gain and little to lose by allomothering

460   due to their reproductive cessation. Studies about *how* grandmothers help across populations

461   have highlighted their roles in food production[25], domestic tasks[56], informational and

462   emotional support [57], as well as financial help [58] and increased maternal labour force

463   participation [59]. Our results support these findings, where grandmothers provided care and

464   substituted maternal childcare. Complementary results have been reported in the Aka hunter-

465   gatherers, where grandmaternal care was associated with a 150 kcal decrease in mother's daily

466   energetic expenditure [13]. One reason why grandmaternal care may readily replace maternal

467   care is that maternal and grandmaternal childcare patterns are similar, focusing on holding and

468   caring. Among the Martu, Scelza [60] found that grandmothers performed more demanding

469   childcare tasks. However, among the Martu, grandmothers were the second most important

470   caregivers (after mothers); a finding not replicated among the Agta. In the Agta, grandmothers

471   were beneficial *when available*, but they rarely were.

472

473   Similar to Hill and Hurtado's [27] findings in the Ache and Hiwi (South American hunter-

474   gatherers), we found that many children did not having a living grandmother. In the Agta, on

475   average, grandmothers were only alive for 15-19 years after last reproduction. Furthermore,

476   even if children had a living grandmother this did not guarantee co-residence, or that the

477   grandmother would provide childcare due to fertility schedules: Fifty-four children had living

478   grandmothers at time of data collection, aged between 38-74 years. Younger grandmothers aged

479   ≤51 years (n = 18) had an average of 6.34 (SD = 2.08) children, of which 2.44 (SD = 1.75) were

480   aged ≤11 years. As such, many grandmothers experienced reproductive conflict with their

Page 17 of 27

Submitted to Phil. Trans. R. Soc. B - Issue

481   daughters, as demonstrated elsewhere[9,61]. For older grandmothers aged ≥52 years (n = 12),

482   while none had children aged under 11, they had on average 20.38 (SD = 11.93) grandchildren,

483   of which 13.25 (SD = 3.96) were aged under 11. Therefore, older grandmothers certainly could

484   not care for all of their grandchildren.

485

486   High fertility and mortality trends combined may explain why many Agta children were not co-

487   resident with grandmothers and did not receive grandmaternal care. Grandmothers cannot be

488   assumed to experience zero- or low-opportunity costs (i.e. they provide care because they do not

489   have their own children) when providing allomaternal care because of overlapping reproductive

490   careers, and their importance may be dependent on the demographic regime leading to

491   contrasting results among different populations [27].

492

493   The duality of play and the allomaternal playgroup

494   These results demonstrate that playgroups collectively provided childcare which did not require

495   adult involvement, and were negatively correlated with maternal childcare. While Konner [39]

496   proposed that one possible function of playgroups was childcare, we know of no research

497   empirically testing this hypothesis. By doing so, our results highlight the potential of playgroups

498   as 'collective allomothers'. Given the ubiquitous presence of playgroups across foraging societies

499   [62], the need of such an investigation is apparent. Playgroups may have been understudied in

500   this domain previous due to 'play' being defined by its lack of current purpose [42], and assumed

501   'function' in the form of longer-term skills development [42,63–65]. Certainly, children gain much

502   from play, however, this does not exclude the duality of 'work-play', where children also make

503   economic contributions [66].

504

505   An interesting question is why the collective effect of playgroups had a negative relationship with

506   maternal childcare, when the individual allomothers had no such effect. Perhaps mothers trusted

507   the 'collective' to provide the type and quality of childcare required to keep younger children out

508   of danger. Our results suggest that the increased play may have meant increased 'active'

509   attention by allomothers, highlighted by playgroups providing the least amount of low

510   investment childcare. Allomothers may be more likely to provide childcare in the playgroup

511   because the costs of childcare are shared among five or ten other individuals [39]. In the diffused

512   form of playgroups, childcare may have little net cost to individual allomothers, particularly if

Submitted to Phil. Trans. R. Soc. B - Issue

Page 18 of 27

513 older members of the playgroup gain key physical, social, emotional and behavioural skills from

514 their participation [17,39], including parenting skills [38]. Measuring the costs and benefits to

515 children within playgroups is an important next step.

516

517 Overall, these results indicate that the role of children as caregivers should not be ignored by

518 researchers. While children caring for children is often conceptualised as harmful in the West

519 [67], our results reiterate the important and positive role children can occupy as caregivers.

520 Indeed, our findings suggest children can be competent caregivers without conflicting with play,

521 challenging the Western notion of the need to "protect" children from caregiving responsibilities

522 [67].

523

524 Siblings and fathers: provisioning rather than childcare?

525 Despite expectations, siblings were not associated with maternal childcare, and therefore did not

526 appear to substitute childcare outside of playgroups. This is surprising since siblings, particularly

527 sisters, provide a significant amount of childcare across a range of small-scale societies [26], and

528 have been associated with improvements in child survivorship and/or health [12,68] as well as

529 maternal fertility [69,70], although not consistently [71,72]. The lack of significant effect in our

530 results may stem from the importance of older siblings conducting domestic tasks [34] as well as

531 food production activities [26,33,73], rather than caregiving, which we are unable to test in the

532 current data. Certainly, siblings are involved in substantial childcare activities; however, the

533 substitutive effect appears limited to playgroups. Similarly, we found that fathers did not

534 substitute maternal childcare. This is not to suggest they were unhelpful, but rather that their

535 major allomaternal contribution is food and resource provisioning, rather than childcare [22].

536 Since male production has gone unmeasured in this study, we are likely underestimating the role

537 of fathers.

538

539 Limitations

540 Anthropological studies of childcare are often frustrated by small sample sizes. Thus, a concern

541 is that a couple of 'unusual' households or days may exert overt influence. Here, we have

542 attempted to maximise sample sizes in order to mitigate against this possibility as much as

543 possible, observeing the majority of children in our study population. Nonetheless, this remains

544 a small and time-limited sample. A second limitation of this work, as highlighted in the discussion

545 above, is that a measurement of provisioning and household tasks is unavailable. Assistance in

546 household tasks, or the provisioning of food both equally 'free up' mothers' time just as childcare

547 does. As a result, our results only paint one-third of the picture; further analysis should reconcile

548 these elements.

549

550 **Conclusions**

551 Our results underline the importance of a wide range of allomothers in supporting Agta mothers.

552 Playgroups were associated with a significant reduction in maternal childcare; something that

553 may be particularly important in high mortality, high fertility environments where grandparents

554 are unlikely to be alive, co-resident *and* able to help. Unrelated children in playgroups are

555 important allomothers, something which has been under-investigated to date. In many

556 populations, children may be a readily available source of childcare, offering important flexibility

557 to mothers. While allomaternal care is certainly a necessity in supporting the unique life-history

558 strategy of humans, we argue that the individuals who provide this care will vary with social

559 structure and demography. Ultimately, a mother's ability to obtain childcare from a wide range

560 of people may be the key to human demographic success.

561

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568

569 **References**

570

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Figures legends

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Figure 1: The kinship composition of childcare from the children's perspective (0-1.9 years, left blue bar and 2-5.9 years, right grey bar). Actual percentages given at top of each bar and represents a count of interactions between all children and different allomothers, converted into a percentage. MGM = maternal grandmother, PGM = paternal grandmother, MGF = maternal grandfather, PGF = paternal grandfather.

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Figure 2: mean proportion of activities spent in either a) low investment, b) playing, c) caring activities and d) holding children for different categories. Error bars represent SEM.

Page 25 of 27

Submitted to Phil. Trans. R. Soc. B - Issue

Tables

Table 1: Mixed-effects model results for the relationship between an instance of allomaternal childcare to a child aged 0-1.9 years and two measures of maternal childcare. MGM = maternal grandmother, PGM = paternal grandmother, MGF = maternal grandfather, PGF = paternal grandfather, extended = extended kin at r = 0.25, distant = distant kin at r < 0.25 & r >= 0.03125 and non = non-kin at r < 0.0325.

	Maternal presence (n = 82,323)				Maternal childcare if present (n = 63,202)			
	OR	L95%CI	U95%CI	p	OR	L95%CI	U95%CI	p
Father	0.721	0.253	2.057	0.541	1.275	0.658	2.470	0.471
Sister	0.572	0.182	1.794	0.338	0.563	0.275	1.151	0.116
Brother	0.613	0.200	1.881	0.393	0.744	0.368	1.506	0.411
MGM	0.930	0.169	5.116	0.933	0.530	0.175	1.607	0.262
PGM	0.011	0.000	0.598	0.027	0.989	0.032	30.250	0.995
MGF	0.802	0.121	5.331	0.819	0.616	0.161	2.353	0.478
PGF	0.590	0.045	7.803	0.689	0.496	0.091	2.707	0.418
Extended Kin	1.181	0.572	2.437	0.653	0.717	0.457	1.125	0.148
Distant Kin	0.969	0.538	1.745	0.917	1.014	0.697	1.475	0.941
Non-kin	1.508	0.878	2.590	0.137	1.616	1.158	2.254	0.005

Submitted to Phil. Trans. R. Soc. B - Issue

Page 26 of 27

Table 2: Mixed-effect model results for the relationship between an instance of allomaternal childcare to a child aged 2-5.9 years and two measures of maternal childcare. MGM = maternal grandmother, PGM = paternal grandmother, MGF = maternal grandfather, PGF = paternal grandfather, extended = extended kin at r = 0.25, distant = distant kin at r < 0.25 & r >= 0.03125 and non = non-kin at r < 0.0325.

	Maternal presence (n = 120,029)				Maternal childcare if present (n = 65,562)			
	OR	L95%CI	U95%CI	p	OR	L95%CI	U95%CI	p
Father	2.066	0.974	4.384	0.059	1.208	0.642	2.274	0.557
Sister	1.078	0.369	3.152	0.890	1.014	0.470	2.186	0.973
Brother	0.956	0.312	2.932	0.937	1.090	0.498	2.384	0.829
MGM	0.105	0.023	0.471	0.003	0.780	0.196	3.098	0.724
PGM	0.541	0.022	13.299	0.707	0.390	0.044	3.480	0.399
MGF	1.685	0.168	16.890	0.657	0.385	0.068	2.178	0.280
PGF	3.951	0.276	56.536	0.311	0.074	0.011	0.520	0.009
Extended kin	2.139	1.014	4.513	0.046	0.932	0.526	1.651	0.810
Distant kin	0.967	0.586	1.594	0.895	0.982	0.590	1.634	0.945
Non-kin	0.773	0.488	1.226	0.274	1.129	0.761	1.676	0.547
Playgroup	0.154	0.145	0.164	0.000	0.339	0.281	0.410	<0.001
Interaction Models: Playgroup x Allomother								
Playgroup	0.168	0.156	0.180	<0.001	0.301	0.243	0.373	<0.001
Sister* Playgroup	0.747	0.654	0.854	<0.001	1.765	1.132	2.752	0.012
Playgroup	0.162	0.152	1.164	<0.001	0.428	0.349	0.526	<0.001
Brother*Playgroup	0.737	0.628	1.875	<0.001	0.276	0.157	0.487	<0.001
Playgroup	0.151	0.142	1.153	<0.001	0.366	0.301	0.445	<0.001
Extended kin* Playgroup	1.306	1.036	2.817	0.024	0.308	0.119	0.791	0.014
Playgroup	0.134	0.125	1.134	<0.001	0.299	0.240	0.374	<0.001
Distant kin* Playgroup	1.967	1.699	5.470	<0.001	1.642	1.071	2.518	0.023
Playgroup	0.159	0.148	1.160	<0.001	0.305	0.244	0.382	<0.001
Non-kin* Playgroup	0.885	0.767	2.153	0.096	1.497	0.977	2.294	0.064

Submitted to Phil. Trans. R. Soc. B - Issue

Page 28 of 27