

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

3
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11
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

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 In contrast to the focus on nuclear families and mother-led childcare in family studies,
83 demography, psychology and public health (Sear, Budds and Hughes et al. this issue), there is a
84 wealth of anthropological literature on the wide range of allomothers in small-scale societies,
85 especially hunter-gatherers,. Hunter-gatherers are populations which rely heavily (but not
86 necessarily exclusively) on hunted, fished or foraged resources. These groups tend to be highly
87 cooperative, widely sharing resources and labour [15]. Mothers in small-scale societies provide a
88 high proportion of childcare [16,17], due to on-demand breastfeeding and close physical contact
89 to mitigate early mortality risks [11,12]. As children age and become more independent maternal
90 childcare decreases [11,16,18,19], suggesting that after weaning the opportunity for
91 allomaternal care increases.

92
93 Some of the earliest research explored paternal care (a form of allomaternal care), hypothesising
94 that male provisioning allowed mothers to redirect their energy from production activities to
95 fertility and childcare, increasing maternal reproduction and child survivorship [20,21]. As
96 highlighted by Sear (this issue), an justification for the 'male-breadwinner nuclear family' ideal is
97 that males had evolved to provision women and children who are unable to provide enough
98 calories to match their consumption[22]. For instance, among Agta foragers, males generally
99 provide the majority of calories, while females spend more time in domestic tasks and childcare

100 [23]. The importance of fathers in hunter-gatherer societies is demonstrated in Gettler et al. (this
101 issue) research in the BaYaka; the stress associated with having fathers who were ineffective
102 providers and less generous sharers was indicated by elevated cortisol levels. While male
103 childcare is high in some populations (e.g. the Aka [24]), fathers typically specialise in provisioning
104 [18], and as such, studies have found that father absence is associated with greater child
105 mortality in a range of pre-industrial societies [25] However, this does not seem to be universal:
106 only 47% of statistically controlled studies (n = 15) reviewed by Sear and Mace [12] found a
107 positive relationship between father presence and child survival, which may be because
108 contributions from fathers can be replaced by other allomothers [11]. Fathers are not the only
109 breadwinners, nor supporters of women and children.

110
111 Studies have investigated grandmothers as key allomothers given their close genetic relationship
112 with grandchildren and reduced caring responsibilities [26]. In support, Sear and Mace [12] found
113 that maternal grandmother presence was most consistently positively correlated with child
114 survival (64% of 11 statistically controlled studies in natural fertility populations). However, a
115 number of studies, particularly in hunter-gatherer/subsistence farming populations, have
116 indicated that grandmothers have little allomaternal involvement, both in terms of direct
117 childcare [18,27] and provisioning [28]. For example, among Aché foragers, only ~10% of females
118 in their 30s co-resided with their mothers [28]. For most mothers, grandmothers were not
119 available as allomothers.

120
121 Overall, fathers and grandmothers are sometimes, but not always, available as important
122 allomothers. Interestingly, there is increasing cross-cultural evidence that children become
123 'helpful' in terms of household tasks, food production and childcare after 6-7 years of age
124 [3,29,30]. Demographic studies highlight considerable levels of juvenile contributions [31,32],
125 particularly in high-fertility societies with large siblings cohorts and few educational
126 commitments [33]. Children provide significant help to their siblings and mothers, ensuring
127 positive energy balances, and ultimately, household survival [27,34,35]. As a result, we expect
128 siblings to be important allomothers in high-fertility populations.

129
130 It is important to note that, under cooperative childrearing, mothers are not restricted to receive
131 help from kin, but may receive help from *anyone* [36]. In fact, the best cooperative strategy for

132 successful reproduction is likely to be a flexible one, depending on which allomothers are
133 present, willing and able [5,33]. Meehan, Helfrecht and Malcom [37] indicate that mothers and
134 children's social networks are composed of a wide range of individuals and households are rarely
135 dependent on a single type of allomother. Evidence suggests that non-relatives gain direct
136 benefits from allomaternal childcare, such as having someone available to help your own children
137 in return [38] or learning key parenting skills to improve child survival [39]. Indeed, several studies
138 have indirectly shown that a considerable amount of allomaternal caregiving is provided by non-
139 relatives [11,18,28]. Despite this evidence, evolutionary-based questions on childcare continue
140 to focus on close, adult relatives. This issue is not limited to evolutionary anthropology, as
141 pointed out by Hughes et al. (this issue) the public health literature on early child development
142 has an almost universal focus on mothers and other close family members, without mention of
143 formal or informal childcare.

144
145 A common feature of social life across hunter-gatherer societies is the formation of mixed-age
146 mixed-sex playgroups, where children and young teens from different households play. The
147 literature on playgroups in hunter-gatherers is extensive, with surprisingly similar descriptions of
148 children collectively roaming, with freedom, around the camp and the surrounding areas [19,40–
149 42]. These playgroups comprise of children aged ≥ 2 years, often without adult supervision [41].
150 Studies have often focused on the function of play behaviours from a developmental perspective
151 [43]. However, playgroups also provide protection, care, teaching and stimulation to younger
152 children [17,40]. Despite this, playgroups have not been empirically explored as a form of
153 childcare in the cooperative childrearing literature. If playgroups allow mothers to reduce their
154 caregiving, then playgroups may be an important facilitator for multiple, overlapping dependant
155 offspring.

156
157 *Current Aims*
158 This paper aims to move beyond the focus on kin as allomothers and explores allomaternal care
159 from the entirety of a child's social network. In doing so, it offers important insights into the
160 dynamics of cooperative childrearing in humans. In particular, we investigate whether direct
161 caregiving by non-kin, juvenile playgroups, as well as relatives (fathers, siblings, grandparents,
162 aunts and uncles and cousins) reduces maternal childcare in a hunter-gatherer population, the
163 Agta. Using in-depth observations of 78 children, we test the degree to which allomaternal

164 childcare is substitutive of maternal childcare, implicitly allowing her to re-invest energy into
165 other domains. Once the overall substitutive role of allomaternal care is established, we then
166 compare the importance of fathers, siblings, grandparents, distant and non-kin as well as
167 playgroups.

168
169 As observed in other hunter-gatherer societies, we hypothesise that childcare is provided by a
170 wide range of individuals among the Agta, but that siblings and non-related juveniles in
171 playgroups will be particularly important caregivers. In contrast, we expect fathers to have a small
172 role in caregiving given their focus on food production [23]. Further, we hypothesise that the
173 effect of grandmothers will be limited due to their high mortality and high residential mobility
174 within the population (meaning grandmothers are likely to live elsewhere) [44,45]. Specifically,
175 we predict that: 1) allomaternal childcare from fathers and grandmothers will have no
176 relationship with maternal childcare; 2) childcare from individual siblings will have a negative
177 relationship with maternal childcare, indicating substitution; and 3) allomaternal care from
178 playgroups (including siblings, distant and non-kin juveniles) will be negatively associated with
179 maternal childcare, also indicating substitution.

180 181 **Methods**

182 183 The Agta

184 There are around 1,000 Agta living in the Palanan municipality of north-eastern Luzon,
185 Philippines. Riverine and marine spearfishing provides their primary source of animal protein,
186 supplemented by hunting and gathering, as well as low-intensity cultivation, wage labour and
187 trade [23,46]. The Agta are bilocal [47], meaning children are equally likely to reside with either
188 their mother's or father's family [48]. As the Agta frequently change residential camp, children
189 will likely spend time with a wide range of kin and non-kin over the course of their childhood.
190 Previous research has highlighted their extensive cooperation, between kin and non-kin, in the
191 domains of food sharing and childcare [38,48–50]. The Agta practice serial monogamy and have
192 a total fertility rate of 7.7 [44] and a short average interbirth interval of 2.8 years. Infant and
193 childhood mortality rates are high, with an estimated 38.9% of offspring dying before the age of
194 16 years [44]. Mortality is higher for males throughout childhood and early adulthood; however,

195 the high costs of reproduction mean that females are increasingly underrepresented in older
196 cohorts [45].

197
198 The Agta style of childcare, like most other hunter-gatherers, has been labelled as indulgent,
199 affectionate and intensive where infants are permanently held, cuddled or played-with [16,46].
200 Children are breastfed on-demand for approximately two years (as observed during our fieldwork
201 and reported approximately by mothers). Young children aged 0-2 years are frequently carried
202 by mothers, usually in fabric slings [51]. As children are weaned they are carried less frequently,
203 watched less intensively, and have significant freedom within camp as they start to participate in
204 mixed-age, mixed-sex playgroups [16,46,52]. As documented in other populations [3,29,30],
205 while younger children spend the time as they like, children after the age of six become
206 increasingly involved in the household economy and provide childcare to younger siblings
207 [16,46,51].

208
209 Data collection
210 Data collection occurred over two field seasons from April-June 2013 and February-October
211 2014. In the first season we censused 915 Agta individuals (54.7% which were male) across 20
212 camps. Following relative aging protocols [53], accurate ages were established for all individuals
213 post data collection. Relatedness was established from household genealogies (involving both
214 mothers and fathers; see [45,48]). In the second season we stayed approximately 10-14 days in
215 ten camps to conduct focal follows of children.

216
217 Focal follows were conducted with 78 children across 10 study camps: 34 children aged 0-1.9 and
218 44 children aged 2 – 5.9. These two age groupings we made based on the observation that
219 children are still intensively breastfed up until the age of two, while we considered children over
220 the age of 6 to be providing more allomaternal care than he/she received (a decision we made
221 during our fieldwork, prior to any analyses). No formal sampling techniques were used due to the
222 small population size, as we were able to observe the majority of children within the study camps
223 (Table S1). Where we were unable to observe all children in a camp, we observed at least one
224 child per household. Although our total sample contains more boys than girls (48 males, 61.54%),
225 this is in line with the male-biased sex ratio seen in the 0-5 year cohort in this population[45].

226

227 Recording allomothering

228 Two researchers (A.E.P and S.V), observed a focal child for a 9-hour period (see [13] for protocol).
229 These observations were broken into 3x 4-hour intervals (6:00 – 10:00, 10:00 – 14:00 and 14:00
230 – 18:00) with a 15-minute break at each hour, and each 4-hr observation was conducted on non-
231 consecutive days to reduce any sampling bias. During observation, researchers recorded the
232 activities of the focal child every 20 seconds, including who came within 3m of the focal child,
233 and the nature of their interaction.

234
235 Information on mothers was recorded regardless of the 3m proximity to the focal child. Where
236 observable (common due to the open nature of camps), activities of the mother were recorded
237 (which included: providing high-investment childcare for the focal child such as carrying/holding,
238 playing; engaging in childcare of another child; household tasks; leisure; being present but not
239 actively engaging in a task and; food production). If the mother was absent, but the observer
240 knew the maternal activity based on reports from family members or neighbours (i.e. individual
241 x has gone to collect water), then this activity was recorded for the mother until she returned.
242 Otherwise, if the mother was absent, she was recorded as ‘not present’.

243
244 For allomothers, their presence and information on their activities were recorded if they were
245 within three meters of the focal child. During data collection, only individuals estimated to be 6
246 years+ were recorded as allomothers. Once accurate ages had been produced, records of
247 ‘allomothers’ aged below 6 years were removed from the analysis. If a focal child was involved in
248 a playgroup (defined as when three or more children (adults could also be involved) engaged
249 collectively in a play activity or roamed around the camp [40]) then the observer recorded the
250 playgroup as a binary event (yes or no), for each of the individuals involved in the playgroup,
251 during each observation interval.

252
253 Prior to the main data collection, both researchers piloted the methodology and were in close
254 agreement about childcare/activity categories. In the following analyses, childcare by mothers
255 and allomothers has been categorised into low-investment childcare (passive engagement; being
256 within three-meter proximity and watching a child) or high-investment childcare
257 (carrying/holding, playing, grooming, cleaning or providing medical attention,

258 feeding/breastfeeding, teaching or otherwise stimulating a child; see Table S2). Throughout this
259 paper, *childcare* refers to both low- and high-investment activities, unless otherwise specified.

260 Data analysis

261 *Chi-squared analysis*

262 To test whether allomaternal childcare was substitutive overall, we explored whether maternal
263 activity budgets were correlated with allomaternal caregiving (regardless of type or source). Chi-
264 squared proportion tests compared the proportion of time allocated to different tasks between
265 1) mothers looking after a child alone, and 2) mothers with allomaternal help.

266

267 *Logistic multilevel models*

268 The association between allomothers and maternal childcare according to the type of allomother
269 was explored with multilevel logistic regression models, with two outcomes. The first outcome
270 was *maternal absence*, coded as 1 for presence and 0 for absence at the point of observation. If
271 a mother is absent, she is not providing childcare to the focal child, thus the allocare is
272 substitutive. The second outcome was *intensity of maternal childcare* (contingent on their
273 presence), coded as 1 if mothers were engaged in active or high-investment childcare or 0 if they
274 were engaged in passive or low-investment childcare. This second outcome explores partially
275 substitutive allocare, where mothers are present (potentially supervising) but can engage in
276 other activities.

277

278 The unit of analysis was each individual instance of childcare between an allomother and the
279 focal child, resulting in a total observational sample size of 202,351 observations from 78 children
280 in 84,240 observational intervals (removing those intervals in which children were alone or only
281 with their mother). To account for the temporal sequencing in the data (i.e. that the first
282 observation will likely predict the second, and third observations etc. with decreasing likelihood
283 over time) the time of the observation is included as a fixed effect to adjust for the non-
284 independence [54]. For children aged 0-1.9 years (n=34 children from 33 households), there were
285 82,322 dyadic interactions between 622 dyads, involving 301 allomothers from 94 households.
286 For children aged >2 years (n=44 children from 36 households), there were 120,029 dyadic
287 interactions between 901 dyads, involving 335 allomothers from 95 households.

288

289 Logistic mixed effect models were carried out in R v 3.2.2 using package Lme4 (function glmer
290 [55]). To take account of clustering, random effects were added at the dyadic level (since each
291 dyad had multiple interactions), the allomother level, the allomother's household, the child's
292 household, and at camp level. Originally, we intended to add the child as a random effect.
293 However, since the majority (88.46%) of households only contributed one child to the sample,
294 we encountered convergence issues. The random effect variance attributed the child level was
295 nil, thus its removal had no impact on the model.

296
297 The main predictor of kin type was modelled as 10 binary dummy variables (0 = no, 1 = yes).
298 Individuals were established as either a: father, brother, sister, maternal grandmother, paternal
299 grandmother, maternal grandfather, paternal grandfather, extended kin ($r = 0.25$, but excluding
300 grandparents as named above), distant kin ($r \geq 0.03125$ & $r < 0.25$) and non-kin ($r < 0.0325$).
301 Therefore, a sister would be recorded as 0 for the father, brother, maternal grandmother,
302 paternal grandmother, paternal grandfather, maternal grandfather, extended, distant and non-
303 kin variables and 1 for the sister variable.

304
305 As playgroups were hypothesised to be of importance (in and of themselves, as well as altering
306 the effect of specific allomothers within playgroups) an additional set of models were run. These
307 models include a predictor term for playgroup (0 = allomother not in a playgroup, 1 = allomother
308 in a playgroup), as well as interactions for the different types of participants in playgroups
309 (sisters, brothers, distant, extended and non-kin, defined based on descriptive analysis of the
310 composition of playgroups). These interactions test whether the substitutive effect of care from
311 a particular allomother was altered by being in a playgroup. Due to the lack of playgroups in the
312 0-1.9 sample, the playgroup analysis was only run in the 2-5.9 sample.

313
314 All models contained controls for child age in years (as children receive less care from their
315 mother as they age) and sex (0 = male). The distant kin, extended kin and non-kin models
316 controlled for the allomother's age and sex. Beyond what is presented below, all model outputs
317 are presented in the SI Tables 7-62 for transparency, and results in text are given alongside 95%
318 confidence intervals of the odds ratios (OR). Multiple comparisons were adjusted for using
319 Hochberg correction, and adjusted p-values are given in Table S5.

320

321 *Post-hoc analyses*

322 We conducted post-hoc exploratory analyses on the type of care provided by the three
323 allomother types who were negatively associated with maternal childcare. This post-hoc analysis
324 sought to test whether different allomothers engaged in different types of childcare. Looking at
325 the mean proportion of interactions grandmothers (n= 19), grandfathers (n=18) and playgroups
326 (n=190) spent in either: a) proximity/watching; b) playing; c) caring for; and d) holding a child,
327 permutation tests were run to explore if the means significantly differed between the groups;
328 100,000 simulations shuffled the existing data randomly to produce 100,000 simulated mean
329 differences. The p-value is then produced based on the number of times out of 100,000 that the
330 simulated mean difference was either higher or lower than (or equal to) the mean difference of
331 the actual sample.

332

333 **Results**

334

335 Descriptive statistics

336

337 *Who cares?*

338 Across the 78 children, 75 received childcare from their mothers (96%), 69 from fathers (88%),
339 22 and 8 from their maternal and paternal grandmothers, respectively (28% and 10%), and 23
340 and 13 from their maternal and paternal grandfathers, respectively (29% and 17%, Table S3). In
341 total, children interacted with 75 sisters (per child: mean = 0.962, SD = 1.167) and 75 brothers
342 (per child: mean = 0.915, SD = 1.200), as well as 366 distant kin (per child: mean = 4.690, SD =
343 3.447), 173 extended kin (per child: mean = 2.218, SD = 2.049) and 703 non-kin (per child: mean
344 = 8.949, SD = 5.748).

345

346 Figure 1 outlines the patterns of childcare children received from mothers and allomothers (See
347 Figures S1 and S2 for the caregiver's perspective). For children aged 0-1.9 years, mothers
348 provided the majority of childcare (25.9% of all caregiver-child interactions), followed by non-kin,
349 distant kin and extended kin. Siblings and fathers were involved in 7.23-8.4% of caregiver-child
350 interactions, and grandparents in 0.3-3%. For children aged 2-5.9 years, non-kin (23.81%) rather
351 than mothers (18.98%) provided the most childcare. Fathers, brothers and sisters had higher
352 levels of childcare involvement (ranging from 7.7-12.8%). Maternal grandparents (1-1.9%) as well

353 as other extended family members were less involved in childcare. Paternal grandparents'
354 involvement was notably low at 0.3-0.6%.

355

356 *Grandmothers' availability and participation*

357

358 Averaged across the population, grandmothers provided little childcare because they were
359 frequently not present (Figure S3). Only 43 (55.13%) and 34 (43.59%) of children had a maternal
360 and paternal grandmother alive, respectively. Across 78 children, 25 co-resided (in the same
361 camp) with a maternal grandmother (32.05% of all children; 58.14% of children with maternal
362 grandmothers alive), and 11 with paternal grandmothers (14.10% of all children; 32.35% of
363 children with paternal grandmothers alive). Overall, only 22 (28.21%) and 8 (10.26%) children
364 ever received low-investment care from their maternal or paternal grandmother, respectively.
365 For grandmothers who co-resided with focal children, 88.0% of maternal grandmothers and
366 72.73% of paternal grandmothers were ever observed to provide low-investment childcare. A
367 comparable result was found for high-investment activities (17 children received high-
368 investment care from maternal grandmothers, equating to 21.8% of all children, or 68% with
369 maternal grandmothers co-residing; 7 children received high-investment care from paternal
370 grandmothers, equating to 8.97% of all children, or 63.64% with paternal grandmothers co-
371 resident). While maternal grandmothers were more likely to be alive, present and provide
372 childcare compared to paternal grandmothers (Table S4), our results indicate that, overall, both
373 grandmother types were frequently *not* present in camp, and when they were, they did not
374 necessarily provided care to grandchildren.

375

376 *Playgroups*

377 In playgroups, the average age of the focal children was 3.94 (SD = 1.28), while the average age
378 of the allomothers was 9.85 (SD = 5.16). Only 1.8% of total observations in the 0-1.9 age group
379 were in playgroups (which occurs mainly from children aged 1.5 – 2 years), while a total of 12.9%
380 (observations n = 19,130) of the 2-5.9 sample's observations were in playgroups. The majority of
381 focal children's interactions in playgroups were with children aged 6-11 years (n = 16,548, 78.3%),
382 while interactions with adolescents aged 11-16 years comprised of 17.3% (n = 3,655) followed by
383 interactions with individuals aged 16 + years (n = 934, 4.3%). The majority of individuals in the
384 playgroup came from kin categories with a higher proportion of juveniles: sisters (23.5%);
385 brothers (14.22%); distant kin (25.35%); extended kin (4.34%) and non-kin (31.49%). Adults had

386 very little, if any, involvement in playgroups: collectively, parents and grandparents consisted of
387 less than 1% of playgroup members. To summarise, this suggests that playgroups can be
388 considered as *en masse* play/childcare for children aged 2-6 years by children aged 6-11 years,
389 with some lesser involvement of adolescents, without direct adult supervision.

390

391 Chi-square results

392 Mothers whose children received allomaternal care, compared to mothers looking after children
393 alone, spent 15.14 percentage points ($\chi^2 = 240.3$, $p < 0.001$, 95% CI [13.37, 16.90]) less time
394 providing childcare in the 0-1.9 sample, and 61.11 percentage points in the 2-5.9 sample ($\chi^2 =$
395 1493.4, $p < 0.001$, 95% CI [58.19, 63.94]). Instead, mothers receiving allomaternal care spent
396 significantly more time in food production, childcare of other children, leisure time and in
397 domestic tasks (SI Tables S6A and S6B). Therefore, overall allomaternal care was substitutive
398 rather than additive in the Agta.

399

400 Logistic multilevel models results

401 *Model set A: predicting mother presence*

402 In the following models, an odds ratio (OR) above 1 represents an increase in maternal childcare,
403 while an OR under 1 reflects a decrease in maternal childcare (Table 1 and 2, also see Figure S4A
404 and S5A). In the 0-1.9 years sample, child age was negatively correlated with maternal presence
405 (OR = 0.027, 95% CI [0.004, 0.1837], $p < 0.001$); a trend which was less strong in the 2-5.9 cohort
406 OR = 0.562, 95% CI [0.413, 0.7651], $p < 0.001$). Overall, fathers did not provide substitutive care
407 for mothers. In contrast, care from grandmothers and playgroups were associated with a
408 decreased likelihood of maternal presence. For children 0-1.9yrs, childcare by paternal
409 grandmothers was negatively associated with maternal presence (OR = 0.011, 95% CI [0.0002,
410 0.598], $p = 0.027$). Note, the 95% CI is wide due to the small number of paternal grandmothers,
411 thus the point estimates may be unreliable. For children 2-5.9yrs, maternal presence was
412 negatively predicted by maternal grandmothers (OR = 0.105, 95% CI [0.023, 0.471], $p = 0.003$)
413 and playgroup participation (OR = 0.154, 95% CI [0.145, 0.164], $p < 0.001$). While other
414 allomothers were not independently associated with maternal presence, this association
415 changed when the allomothers were part of a playgroup: brothers *within playgroups* were
416 associated with a lower odds of maternal presence (OR = 0.120, 95% CI [0.104, 0.138], $p < 0.001$),

417 as were sisters (OR = 0.125, 95% CI [0.119, 0.140], $p < 0.001$), extended kin (OR = 0.198, 95% CI
418 [0.158, 0.247], $p < 0.001$), distant kin (OR = 0.264, 95% CI [0.232, 0.301], $p < 0.001$) and non-kin
419 (OR = 0.140, 95% CI [0.124, 0.159], $p < 0.001$) (Interaction models; Table 2). Therefore, within
420 playgroups, all previously non-substitutive kin categories were negatively correlated with
421 maternal presence.

422

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

424 As with the maternal presence models, child age was negatively correlated with maternal
425 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%
426 CI [0.215, 0.371], $p < 0.001$). Overall, grandmothers did not predict a reduction in maternal
427 childcare in either age group, nor did fathers (Table 1 and 2, also see Figure S4B & S5B). As before,
428 in the 2-5.9yrs age group, individuals *within playgroups* were significantly associated with
429 reduced likelihoods of maternal childcare. Brothers in playgroups were associated with a lower
430 odds of maternal childcare (OR = 0.118, 95% CI [0.070, 0.201], $p < 0.001$), as were sisters (OR =
431 0.532, 95% CI [0.361, 0.784], $p < 0.001$), extended kin (OR = 0.113, 95% CI [0.044, 0.284], $p <$
432 0.001), distant kin (OR = 0.492, 95% CI [0.342, 0.709], $p < 0.001$) and non-kin (OR = 0.457, 95% CI
433 [0.317, 0.657], $p < 0.001$) (Interaction models; Table 2). Furthermore, in the over-tuos, paternal
434 grandfather care was associated with a reduction of maternal childcare when mothers were
435 present (OR = 0.073, 95% CI [0.010, 0.522], $p = 0.009$). The opposite is true of non-kin allomothers
436 in the under-tuos (OR = 1.616, 95% CI [1.158, 2.253], $p = 0.005$) suggesting that mothers did not
437 allow non-kin to provide solo-childcare to younger children.

438

439 Post-hoc analyses

440

441 From the above analysis, three categories of alloparents were negatively associated with
442 maternal childcare: grandmothers, grandfathers and playgroups. Further explorative
443 permutation tests demonstrated different patterns of childcare (Figure 2; see Table S6A and S6B).
444 Grandmothers, compared to individuals in playgroups, held children more (0.113 vs. 0.019, $p =$
445 0.002), suggesting a pattern of care similar to mothers (Figure 2C and D). Unsurprisingly,
446 individuals in playgroups played with children significantly more than grandmothers (0.172 vs.
447 0.014, $p < 0.001$) and grandfathers (0.172 vs. 0.023, $p = 0.001$). In contrast, the only activity
448 grandfathers did more of was low-investment proximity/watching, compared to playgroups

449 (0.922 vs. 0.948, $p < 0.001$) and grandmothers (0.867 vs. 0.948, $p = 0.044$). Thus, grandfathers
450 provided extremely little 'intensive' childcare compared to all other categories.

451

452 **Discussion**

453 In the Agta, a large number of individuals were involved in providing childcare, coming from a
454 range of kin and age categories. Overall, allomaternal childcare was associated with a reduction
455 in maternal childcare. These results demonstrate that mothers who received help spent less time
456 caring for that particular child and more time in other activities, such as economic tasks, caring
457 for other children and leisure time. Thus, allomaternal care in the Agta can be considered
458 substitutive rather than additive. While we have yet to explore why care is substitutive, such
459 trends are likely influenced by ecological context, dependent on which strategies have the
460 highest fitness payoffs [8]. For instance, allomaternal care in the Agta *may* be substitutive since
461 mothers, in general, appeared to invest in high fertility due to ecological risks [44,45] limiting the
462 fitness payoff of the increased childcare associated with additive care. Further investigation
463 should explore the relationship between allomothering, environmental pressures, activity
464 budgets and fertility trends. It is important to reinforce that childcare, like any form of social
465 support, cannot be assumed to produce positive outcomes, as highlighted by Shenk *et al* (this
466 issue) when looking at women's nutritional condition and Myers *et al*. (this issue) exploration of
467 length of breastfeeding dependent on the type of support. The mechanism by which support
468 impacts maternal behaviour are key and, thus, require further investigation. Here, we have
469 highlighted that maternal behaviour is also dependent on who provides childcare, as it was
470 grandmothers and playgroups who substituted mothers.

471

472 **Absent, but helpful, grandmothers**

473 Much attention has been paid to grandmothers as important allomothers[56]. In terms of
474 inclusive fitness, grandmothers arguably have much to gain and little to lose by allomothering
475 due to their reproductive cessation. Studies about *how* grandmothers help across populations
476 have highlighted their roles in food production[26], domestic tasks[57], informational and
477 emotional support [58], as well as financial help [59] and increased maternal labour force
478 participation [60]. Our results support these findings, where grandmothers provided care and
479 substituted maternal childcare. Complementary results have been reported in the Aka hunter-

480 gatherers, where grandmaternal care was associated with a 150 kcal decrease in mother's daily
481 energetic expenditure [13]. One reason why grandmaternal care may readily replace maternal
482 care is that maternal and grandmaternal childcare patterns are similar, focusing on holding and
483 caring. Among the Martu, Scelza [61] found that grandmothers performed more demanding
484 childcare tasks. However, among the Martu, grandmothers were the second most important
485 caregivers (after mothers); a finding not replicated among the Agta. In the Agta, grandmothers
486 were beneficial *when available*, but they rarely were.

487
488 Similar to Hill and Hurtado's [28] findings in the Ache and Hiwi (South American hunter-
489 gatherers), we found that many children did not have a living grandmother. In the Agta, on
490 average, grandmothers were only alive for 15-19 years after last reproduction. Furthermore,
491 even if children had a living grandmother this did not guarantee co-residence, or that the
492 grandmother would provide childcare due to fertility schedules: Fifty-four children had living
493 grandmothers at time of data collection, aged between 38-74 years. Younger grandmothers aged
494 ≤ 51 years ($n = 18$) had an average of 6.34 (SD = 2.08) children, of which 2.44 (SD = 1.75) were
495 aged ≤ 11 years. As such, many grandmothers experienced reproductive conflict with their
496 daughters, as demonstrated elsewhere [9,62]. For older grandmothers aged ≥ 52 years ($n = 12$),
497 while none had children aged under 11, they had on average 20.38 (SD = 11.93) grandchildren,
498 of which 13.25 (SD = 3.96) were aged under 11. Therefore, older grandmothers certainly could
499 not care for all of their grandchildren.

500
501 High fertility and mortality trends combined may explain why many Agta children were not co-
502 resident with grandmothers and did not receive grandmaternal care. Grandmothers cannot be
503 assumed to experience zero- or low-opportunity costs (i.e. they provide care because they do not
504 have their own children) when providing allomaternal care because of overlapping reproductive
505 careers, and their importance may be dependent on the demographic regime leading to
506 contrasting results among different populations [28]. As argued by Sear (this issue), cooperative
507 childrearing is not all sweetness and light as the need for cooperation within the family may fuel
508 conflict as a grandmother can become a sought-after resource.

509
510 The duality of play and the allomaternal playgroup

511 These results demonstrate that playgroups collectively provided childcare which did not require
512 adult involvement, and were negatively correlated with maternal childcare. While Konner [40]
513 proposed that one possible function of playgroups was childcare, we know of no research
514 empirically testing this hypothesis. By doing so, our results highlight the potential of playgroups
515 as ‘collective allomothers’. Given the ubiquitous presence of playgroups across foraging societies
516 [63], the need of such an investigation is apparent. Playgroups may have been understudied in
517 this domain previous due to ‘play’ being defined by its lack of current purpose [43], and assumed
518 ‘function’ in the form of longer-term skills development [43,64–66]. Certainly, children gain much
519 from play, however, this does not exclude the duality of ‘work-play’, where children also make
520 economic contributions [67].

521
522 An interesting question is why the collective effect of playgroups had a negative relationship with
523 maternal childcare, when the individual allomothers had no such effect. Perhaps mothers trusted
524 the ‘collective’ to provide the type and quality of childcare required to keep younger children out
525 of danger. Our results suggest that the increased play may have meant increased ‘active’
526 attention by allomothers, highlighted by playgroups providing the least amount of low
527 investment childcare. Allomothers may be more likely to provide childcare in the playgroup
528 because the costs of childcare are shared among five or ten other individuals [40]. In the diffused
529 form of playgroups, childcare may have little net cost to individual allomothers, particularly if
530 older members of the playgroup gain key physical, social, emotional and behavioural skills from
531 their participation [17,40], including parenting skills [39]. Measuring the costs and benefits to
532 children within playgroups is an important next step.

533
534 Overall, these results indicate that the role of children as caregivers should not be ignored by
535 researchers. While children caring for children is often conceptualised as harmful in the West
536 [68], our results reiterate the important and positive role children can occupy as caregivers.
537 Indeed, our findings suggest children can be competent caregivers without conflicting with play,
538 challenging the Western notion of the need to “protect” children from caregiving responsibilities
539 [68].

540
541 Siblings and fathers: provisioning rather than childcare?

542 Despite expectations, siblings were not associated with maternal childcare, and therefore did not
543 appear to substitute childcare outside of playgroups. This is surprising since siblings, particularly
544 sisters, provide a significant amount of childcare across a range of small-scale societies [27], and
545 have been associated with improvements in child survivorship and/or health [12,69] as well as
546 maternal fertility [70,71], although not consistently [72,73]. The lack of significant effect in our
547 results may stem from the importance of older siblings conducting domestic tasks [35] as well as
548 food production activities [27,34,74], rather than caregiving, which we are unable to test in the
549 current data. Certainly, siblings are involved in substantial childcare activities; however, the
550 substitutive effect appears limited to playgroups. Similarly, we found that fathers did not
551 substitute maternal childcare. This is not to suggest they were unhelpful, but rather that their
552 major allomaternal contribution is food and resource provisioning, rather than childcare [23].
553 Since male production has gone unmeasured in this study, we are likely underestimating the role
554 of fathers.

555

556 Limitations

557 Anthropological studies of childcare are often frustrated by small sample sizes. Thus, a concern
558 is that a couple of 'unusual' households or days may exert overt influence. Here, we have
559 attempted to maximise sample sizes in order to mitigate against this possibility as much as
560 possible, observing the majority of children in our study population. Nonetheless, this remains a
561 small and time-limited sample. A second limitation of this work, as highlighted in the discussion
562 above, is that a measurement of provisioning and household tasks is unavailable. Assistance in
563 household tasks, or the provisioning of food both equally 'free up' mothers' time just as childcare
564 does. As a result, our results only paint one-third of the picture; further analysis should reconcile
565 these elements.

566

567 Conclusions

568 Our results underline the importance of a wide range of allomothers in supporting Agta mothers.
569 Playgroups were associated with a significant reduction in maternal childcare; something that
570 may be particularly important in high mortality, high fertility environments where grandparents
571 are unlikely to be alive, co-resident *and* able to help. Unrelated children in playgroups are
572 important allomothers, something which has been under-investigated to date. In many

573 populations, children may be a readily available source of childcare, offering important flexibility
574 to mothers. While allomaternal care is certainly a necessity in supporting the unique life-history
575 strategy of humans, we argue that the individuals who provide this care will vary with social
576 structure and demography. Ultimately, a mother's ability to obtain childcare from a wide range
577 of people may be the key to human demographic success.

578

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585

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789 **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.

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.

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 $r < 0.25$ & $r \geq 0.03125$ 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

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 $r < 0.25$ & $r \geq 0.03125$ 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