Land inheritance establishes sibling competition for marriage and reproduction in rural Ethiopia

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Intergenerational transfer of wealth has been proposed as playing a pivotal role in the evolution of human sibling relationships. Sibling rivalry is assumed to be more marked when offspring compete for limited heritable resources, which are crucial for reproductive success (e.g., land and livestock); whereas in the absence of heritable wealth, related siblings may cooperate. To date, comparative studies undertaken to support this evolutionary assumption have been confounded by other socioecological factors, which vary across populations, e.g., food sharing and intergroup conflict. In this article we explore effects of sibling competition and cooperation for agricultural resources, marriage, and reproduction in one contemporary Ethiopian agropastoralist society. Here recent changes in land tenure policy, altering transfers of land from parents to offspring, present a unique framework to test the importance of intergenerational transfers of wealth in driving sibling competition, while controlling for socioeconomic biases. In households where land is inherited, the number of elder brothers reduces a man's agricultural productivity, marriage, and reproductive success, as resources diminish and competition increases with each additional sibling. Where land is not inherited (for males receiving land directly from the government and all females) older siblings do not have a competitive effect and in some instances may be beneficial. This study has wider implications for the evolution of human family sizes. Recent changes in wealth transfers, which have driven sibling competition, may be contributing to an increased desire for smaller family sizes.

parental investment | local resource competition | demographic transition

Human parents invest intensively in their offspring. Our evolved life history has been shaped by the energetic and time costs of rearing large-brained children who experience a long period of juvenile dependency requiring both parental and grandparental support (1–7). Parents also remain significant investors in their children's success long after sexual maturity through the direct transfers of critical resources, such as land, livestock, status, and other material goods, which help to secure marriage partners and economic security (8). Evolutionary life history theory predicts that the equal division of investment between offspring is neither achievable, as resources diminish with each additional child (9), nor under some conditions may it be optimal, as parents increase their fitness by biasing their investment toward offspring with higher reproductive value (10, 11). Investment patterns vary according to local ecological factors, including resource renewability, extrinsic mortality risks, and population change. Competition between siblings is expected to be greatest, and parental investment more biased, for those resources that are the key determinants of future success, e.g., health care (12), education (13, 14), and heritable wealth (15–18).

Recent anthropological studies in pretransitional societies, however, have found mixed evidence of adult sibling resource competition (19). In some instances positive effects of siblings have been demonstrated, suggesting that the costs to resource division within the family have the potential to be offset by beneficial cooperative activities between siblings (see reviews of human cooperative breeding strategies in refs. 20 and 21). The biggest contrast can be observed between agricultural/pastoralist and hunter-gatherer/forager societies. For example, adult siblings are positively associated with male fertility among African !Kung, and South American Ache hunter-gatherer groups (2, 22). Among Aka foragers in Central Africa, men with more brothers achieve higher status, marry earlier, and attract more marriage partners (23). Conversely, in agricultural and pastoral communities evidence for adult sibling competition is more apparent. Large numbers of siblings (particularly elder brothers) reduce wealth inheritance, inhibit marriage opportunities (marriage payments and bride choice) (17, 18, 24–26), increase adult mortality (27), and in most cases, reduce an individual's lifetime reproductive success. It is often assumed that sibling rivalry is more marked in these populations, because adult male siblings are in greater competition for individually owned and inelastic forms of heritable wealth, particularly land and livestock, which are crucial for reproductive success.

In societies where intergenerational transfers of resources are less important (e.g., hunter-gatherers), siblings are highly cooperative in food acquisition and juvenile care (28). Elder siblings may become a relative asset to the household (and in doing so improve their inclusive fitness) through contributions in subsistence (29), domestic labor, or assistance with child care of their younger siblings (30, 31). Similar support is provided by elder daughters who do not compete for inheritance in small-scale agricultural societies (32, 33).

However, a simple comparison of studies carried out across different cultural groups does not provide strong evidence that wealth transfers define the nature of adult sibling relationships. Other cultural and subsistence practices also vary between groups, including levels of polygamy (34), proximity of kin (29), dependence on large unpredictable food resources (e.g., meat sharing among hunters (22, 29, 35), and threat of intergroup conflict (22). All of these factors could independently alter local returns to parental investment or influence alliances of cooperating kin. Current studies also differ in their adjustment for relevant socioeconomic variation (and associated phenotypic correlations) between families, which may distort the consequences of sibling competition. For example, sibling rivalry may be more evident in agricultural and pastoral populations partly because it is easier to measure and adjust statistically for differences in resource access between families (19).

This article explores the extent to which wealth transfer systems shape sibling relationships and parental investment tradeoffs in one contemporary Ethiopian agropastoralist society, where recent

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changes in land tenure policy have altered the nature of transfers of resources from parents to offspring (Table 1). In addition we identify how this has also impacted on desired family sizes.

We test for (*i*) any effects of birth order and sibling configuration (number of elder or younger, same sex, or opposite sex siblings) on agricultural productivity, marriage opportunities (age at first marriage and marriage payments), and reproductive success (age-specific surviving offspring); (*ii*) variation in these sibling effects according to wealth inheritance systems, between households in which sons receive broadly equal plots of land from the government ("the redistribution recipients," $n = 411$) and those households in which parents divide up and share out land among their male offspring ("the inheritors," $n = 520$); and also (*iii*) variation in sibling effects between the sexes, between sons who inherit or receive distributions and daughters who do not.

This study has at least three key strengths: (*i*) It adopts a natural experimental framework that explores variation within one population, thus controlling for any confounding and/or unmeasured effects of cultural or subsistence practices that influence sibling relationships. Further, using appropriate statistical techniques we control for other differences in wealth, age, and status between subgroups. (*ii*) We use rich anthropological, demographic, and socioeconomic data from five traditional rural villages in Ethiopia (Table S1), where wealth remains positively correlated with reproductive success (characteristic of preindustrial societies). (*iii*) These villages are on the cusp of the fertility transition (fertility is high, mortality is declining), a situation that can offer insight into the evolutionary processes underpinning parents' decisions to increase their investment in fewer offspring.

Results

We found evidence that in a contemporary, high-fertility, agropastoralist population, the extent to which adult siblings compete or cooperate with each other in marriage and reproduction is strongly influenced by the presence or absence of heritable wealth.

Land Productivity. Among males who have inherited land from their parents, agricultural productivity (total crop yield in the previous year's harvest, measured in quintals) declines with number of older brothers, indicating a trend for later born sons to inherit increasingly poorer quality parcels of land ($\beta -0.77 \pm 0.41$, $P = 0.07$). It is worth noting that the statistical significance

Table 1. Sibling competition for land, marriage, and reproduction

	Inheritor male	Redistribution male	Female
	Total crop yield in quintals (GLM)		
Model 1	Coefficient ± SE	Coefficient ± SE	Coefficient ± SE
Intercept	7.88 ± 2.85***	10.62 ± 5.19**	NA
Family size	0.07 ± 0.16	−0.26 ± 0.23	NA
Birth order	−0.23 ± 0.85	0.39 ± 0.29	NA
Model 2			
Older brothers	−0.77 ± 0.40*	0.01 ± 0.69	NA
Older sisters	−0.33 ± 0.33	−0.93 ± 0.59	NA
	Age at marriage in years (GLM)		
Model 1	Coefficient ± SE	Coefficient ± SE	Coefficient ± SE
Intercept	19.11 ± 0.72***	17.05 ± 1.32***	17.35 ± 0.26***
Family size	−0.02 ± 0.04	0.06 ± 0.06	−0.00 ± 0.04
Birth order	0.06 ± 0.05	−0.02 ± 0.07	−0.02 ± 0.06
Model 2			
Older brothers	0.30 ± 0.1***	0.06 ± 0.17	−0.07 ± 0.06
Older sisters	−0.01 ± 0.10	0.12 ± 0.20	−0.03 ± 0.06
	Marriage payments in Ethiopian birr		
Model 1	Coefficient ± SE (GLM)	Coefficient ± SE (GLM)	Coefficient ± SE (LOG)
Intercept	2774 ± 368***	2118 ± 394***	−1.97 ± 0.29***
Family size	−24.38 ± 25.17	11.97 ± 17.23	−0.02 ± 0.04
Birth order	49.42 ± 21.04	−28.24 ± 21.50	0.25 ± 0.07***
Model 2			
Older brothers	−182.85 ± 55***	−44.72 ± 53.38	0.20 ± 0.07***
Older sisters	147.96 ± 52.55***	61.95 ± 72.47	0.14 ± 0.90
	Number of surviving offspring (GLM)		
Model 1	Coefficient ± SE	Coefficient ± SE	Coefficient ± SE
Intercept	−1.59 ± 0.38***	1.59 ± 0.85*	0.13 ± 0.25
Family size	0.05 ± 0.02**	0.04 ± 0.04	0.00 ± 0.04
Birth order	−0.04 ± 0.03*	0.01 ± 0.05	0.19 ± 0.06***
Model 2			
Older brothers	−0.00 ± 0.06	0.17 ± 0.12	0.11 ± 0.06*
Older sisters	−0.03 ± 0.06	0.07 ± 0.09	0.07 ± 0.06
Model 3			
First born	Ref	Ref	Ref
All later born	−0.42 ± 0.20**	0.27 ± 0.34	0.32 ± 0.21

Adjusted for age, size of landholdings, father's wives, sibling sex ratio at birth among inheriting males ($n = 520$), noninheriting males (redistribution recipients, $n = 411$), and noninheriting females ($n = 1166$) (*$P < 0.1$, **$P < 0.05$, ***$P < 0.001$). Ref, reference value; GLM, generalized linear model; LOG, logistic regression model.

of this effect may be partly masked due to the difficulties of adjusting for interdependence between general wealth, inherited land-holdings size, and crop yield. Among farmers receiving their plot of land from the government, older siblings of either sex have little measurable effect on productivity (β 0.39 ± 0.29, P = 0.17) (Table 2; the full model can be found in Table S2).

Marriage Opportunities. Overall, there appear to be no effects of birth order or family size on male marriage opportunities, determined by age at first marriage and size of bridewealth payments, contributed by parents in Ethiopian birr (Table 2 and full model in Table S3). However, siblings of different sex have different competitive effects on males who inherit land. Male inheritors are in greatest competition with their elder brothers for marriage opportunities, as number of elder brothers is associated with delays in age at marriage (β 0.30 ± 0.1, P = 0.007) (Fig. 1) and lower bridewealth (β −182.85 ± 55, P = 0.001 (Fig. 2). A first born son marries on average 2 y earlier and with a bridewealth payment approximately one-third higher than a third or later born son. Conversely, number of older sisters has a positive linear effect on a male's bridewealth allocation (β 147.96 ± 52.55, P = 0.005), appearing to almost offset the cost of older brothers (Fig. 2). Indirect transfers of money between elder sisters and younger brothers may be made through marriage payments, i.e., parents use their older daughters bridewealth to obtain high status marriages for their younger sons.

Among males who receive their land from the government, there is no indication of competition between sons for marriage (either by influencing age at marriage (β 0.06 ± 0.17, P = 0.746) or bridewealth payments (β −44.72 ± 53.38, P = 0.40). Cooperative sibling relationships are also indicated for noninheriting females, as there is a linear increase in the likelihood of a daughter receiving a dowry at marriage with birth order (β 0.25 ± 0.07, $P \leq$ 0.001), which appears to be driven almost entirely by the benefits associated with having older brothers (β 0.20 ± 0.07, P = 0.002). An alternative explanation for this pattern could be that later born daughters have an advantage over their older sisters, as they are not in direct competition with first born males (who receive the largest intergenerational transfers of all offspring). This scenario, however, seems less likely, as it assumes parental resources are renewed rather than depleted overtime. Within such an assumption, parents should continue to favor later born sons over daughters (36), reducing relative advantages for the latter over their elder sisters.

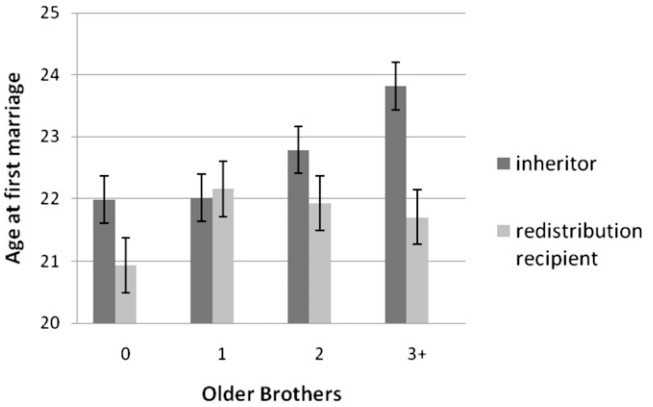

Fig. 1. The effect of older brothers on male age at first marriage by land tenure system. This is presented as marginal means ± SE, adjusted for age, land size, number of father's wives, and sibling sex ratio at birth (inheritor n = 520; redistribution recipient n = 411).

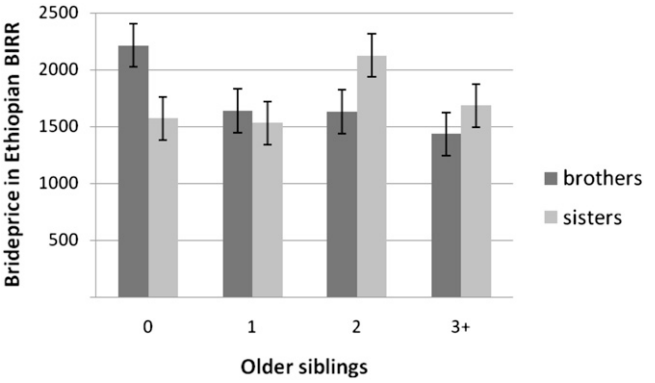

Fig. 2. The effect of older brothers and older siblings on male inheritors' bridewealth payments at first marriage in Ethiopian birr (16 birr = 1 USD). This is presented as marginal means ± SE, adjusted for age, land size, number of father's wives, and sibling sex ratio at birth (male inheritor n = 520).

Age-Specific Surviving Offspring. Overall, with age and wealth adjusted, there is a trend toward fewer surviving offspring for later born males who inherit their land from their parents (β −0.04 ± 0.03, P = 0.08), which is not evident for males who obtained land through government distribution (β 0.01 ± 0.05, P = 0.81). Among inheritors, it is first born males who overall achieve the highest age-specific reproductive success (β 0.42 ± 0.20, P = 0.04) (Fig. 3). Conversely, for females, there is a linear increase in numbers of surviving offspring with birth order (β 0.19 ± 0.06, P = 0.002), which again may be associated with the benefits of having older brothers (β 0.11 ± 0.06, P = 0.06).

Discussion

This paper provides clear evidence that it is the transmission of intergenerational wealth that drives male sibling competition for marriage and reproduction. In Arsi Oromo households where land is inherited, greater numbers of elder brothers reduce a man's agricultural productivity (total crop yield), marriage opportunities (later age and reduced bridewealth payments at first marriage), and reproductive success (surviving offspring), as resources diminish and competition increases with each additional male sibling. Conversely, where wealth is not heritable but distributed equally by the government, older brothers are not detrimental for male marriage or reproduction.

We also demonstrate that noninheriting siblings can be beneficial through the positive effects that noninheriting females exert on their younger brothers, most evident through the indirect exchange of bridewealth resources at marriage. Older sisters' bridewealth payments are used to obtain higher status marriages for younger brothers, and in doing so, offset most of the competitive effects of older brothers. There is also reason to infer that brothers in turn may reciprocate through the transfer of resources that increase both their younger sisters' chances of receiving a dowry and numbers of surviving offspring.

Since the end of government land redistribution programs in the early 1990s, Arsi Oromo agropastoralists have experienced greater competition between brothers for high-quality land and mates, not dissimilar to that recorded in other agricultural and pastoral societies, where land and livestock are crucial for offspring success (17, 18, 24–26). Whereas previous studies have proposed that these effects may be due to competition within the family for heritable resources, the current study demonstrates clearly within a single population that it is the presence or absence of heritable wealth that is the driver for this competition.

Despite current government legislation to encourage the equal division of heritable resources among children, Arsi Oromo parents have adopted a pattern of wealth inheritance that favors

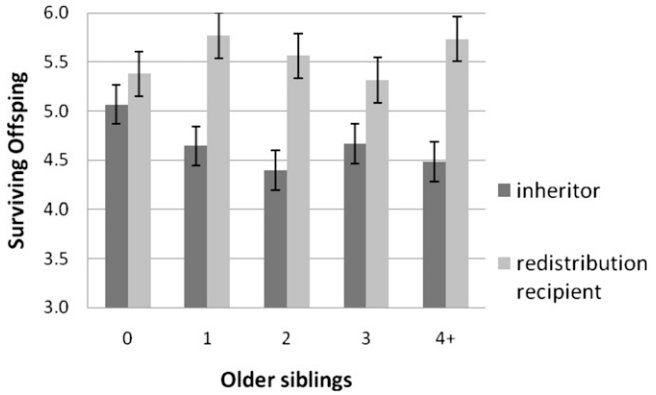

Fig. 3. The effect of older siblings on male reproductive success by land tenure system. This is presented as marginal means ± SE, adjusted for age, land size, number of father's wives, and sibling sex ratio at birth (inheritor $n = 520$; redistribution recipient $n = 411$).

elder sons, who obtain better quality land and higher bridewealth payments. Primogeniture may be one strategy to avoid the further subdivision and fragmentation of their land (37). This changing pattern of parental investment is observed across both childhood— first born sons receive more education than all later born offspring (13, 14) and adulthood— they assume the role of head of household when their fathers die and inherit all nondivisible household resources, e.g., the plow.

The relationship between wealth inheritance, birth placement, and reproductive success fits with predictions from evolutionary parental investment theory: first, that wealth transfers from parents to offspring translate into reproductive success; second, that individual allocation of inelastic resources decreases as competition increases with each additional offspring; and third, that first born offspring are invested in at the expense of all later born offspring, having survived extrinsic mortality risks of childhood and early adulthood and are closest in age to starting reproduction (10), allowing parents more time to contribute to their reproductive success through grandparental investment (37).

Intergenerational transfers of inelastic wealth may also play an important (and often unforeseen) role in initiating changes in desired family sizes (38), as sibling competition for heritable wealth and reproductive decisions are highly interrelated (39). Children with no prospect of any inheritance may contribute little or nothing to parents' long-term fitness. Further, the cost of raising those children may even reduce the potential reproductive success of their siblings by reducing household wealth and limited food supplies.

Among the Arsi Oromo, few nonagricultural income-generating opportunities currently exist, and only 31.2% of school-aged children receive any education, less than 15% spending more than a year in school. Shortages of new land and recent high population growth have resulted in a population at carrying capacity (40). Under these conditions, we argue that increases in sibling competition for high-quality land may represent an important factor underpinning parents' decisions to invest more in a smaller number of offspring.

Table 2. Logistic regression identifying ever-use of contraception among reproductive aged women

	Coefficient ± SE	*P*
Intercept	−1.22 ± 0.59	0.038
Age	−0.003 ± 0.03	0.903
No. of surviving offspring	0.087 ± 0.09	0.317
Husband's inherited land size	−0.606 ± 0.28	0.032

Sample includes ever-married women less than 50 y, $n = 524$.

In support of this argument, we find that heritable resource constraint is driving an increased desire to limit family sizes among the Arsi Oromo, among whom modern contraceptive uptake has increased from <1% to >19% between 1999 and 2009. Among the first to adopt the use of modern contraception are those farmers who have inherited the smallest parcels of land ($\beta - 0.61 \pm 0.28$, $P = 0.032$; Table 2). These findings contribute to growing evidence that competition for inelastic heritable resources, such as land, cattle, and titles, represents an important determinant of the nature of sibling relationships and also parental reproductive decision making (6, 19).

Materials and Methods

Study Population. The Arsi Oromo are agropastoralists who combine cattle rearing with maize, wheat, and sorghum cultivation in the rural low-lying areas of the Arsi region (zone) in Southern Ethiopia. They maintain high fertility and high but recently declining mortality rates (Table S1), which has resulted in recent population growth (40) and increasing land scarcity. Inheritance patterns are patrilineal, a third of men are polygynous, and postmarital residence is predominantly patrilocal (daughters move from their natal village to join their husband's patrilineage at marriage) (41). Accordingly, daughters are considered a drain on household resources, and the Arsi Oromo express a strong cultural preference for sons (36), both in education (13) and in the division of heritable resources, such as land and cattle. The largest intergenerational transfer of heritable resources from parents to offspring occurs upon a child's marriage. At a daughter's marriage 63% receive a small dowry composed of household materials (worth on average 36 USD). At a son's marriage, parents invest considerably more. They provide land holdings for the newly wed couple to farm, and contribute cash bridewealth payments (brideprice), which are transferred to the bride's family. With few income-generating opportunities, bridewealth for sons (on average 80 USD) may take many years for parents to accumulate. High status marriage partners (due to wealth, family status) attract both higher brideprice and have higher reproductive success (41).

Changes in Land Tenure. First settling in the Arsi region in the 1950s, the Oromo experienced dramatic changes to their subsistence economy during the socialist agrarian reform of the 1970s (42). At this time the government introduced countrywide changes to land tenure: nationalizing rural land, abolishing tenancy, and periodically redistributing land among farmers to ensure that individual plot size and quality were broadly equal (43). Since the fall of the socialist government in the early 1990s, parents have returned to a system of bequeathing the same land (or right to use it, as land is still state owned) to their offspring, which the federal legislation dictates should not be less than 0.5 ha (44). High population growth (40), however, and a shortage of productive agricultural land has made equal shares of land over 0.5 ha per child unachievable (none of the Arsi Oromo respondents in this study had access to more than 4 ha of land, and the average plot size was 1.6 ha). Despite this, farmers state their intention to pass on their land by sharing it among male children, most being unaware of regulations concerning minimum land holding size. Bitter competition over access to high-quality land has become common among the younger generation that will inherit plots too small and/or of poor quality to support a family (41% of farms in the region are below the minimum size of land required to attain food security) (45). Elders report that land disputes have shifted from conflicts with neighbors, to previously rare land disputes between fathers and sons and between brothers (44).

Data. Demographic, socioeconomic, and marriage data used in this study were collected from all 931 ever-married men and 1,166 ever-married women resident during a household survey undertaken by the authors in 2009 in five neighboring villages in Hitosa and Dodota *weredas* in the Arsi zone, Oromiya region. This survey also recorded information on livelihoods and inheritance practices. Ethical permissions and research clearance for undertaking this survey were granted by local and national authorities in Ethiopia, and informed consent was obtained from all participants.

Descriptive statistics for the four outcome variables, reflecting total agricultural productivity (total crop yield in quintals), marriage opportunities (age and marriage payments at first marriage), and reproductive success (number of surviving offspring) and key predictor terms (birth order, family size, and sibling configuration) are presented in Table S1. For all adult men, the strongest predictor of land size is the land tenure system. Men who have

inherited their land holdings from their fathers have significantly smaller plots than those who received their land from the government (inheritors, 1.23 ± 0.06 ha; government redistribution recipients, 1.89 ± 0.06 ha). At the survey date, however, not all inheritors had received their full entitlement of inherited land from their parents (i.e., their fathers were still alive). As such, a measure of total agricultural productivity (maize, wheat, and sorghum crop yield in the previous harvest) was used, reflecting the quality of land farmers had access to.

Statistical Analyses. Multivariate analyses were undertaken to assess the partial effects of a range of sociodemographic factors known to influence the dependent variables. This range included age on the survey date, surviving family size (excluding offspring who died before 15), and birth order and sibling configuration, including number of elder or younger, same sex, or opposite sex siblings who survived to 15 y of age. Birth placement was considered more useful than overall number of siblings in this high-fertility population, because wealth is likely to be confounded by family size. Three independent measures of household wealth and status were included: land holding size, total number of fathers' marriages, and sibling sex ratio at birth (including dead siblings). The latter was included as a previous study had indicated that a secondary sex ratio biased toward males was a measure of well-being in this population (46).

To test how heritable resource acquisition influences sibling competition for land, marriage, and reproduction across three groups (male inheritors, male redistribution recipients, and all females), three separate analyses were undertaken. The "redistribution recipients" included individuals who received their land from the government, during redistribution programs between 1975 and 1990 (n = 411), whereas "inheritors" received their share of land (or rights to use that land) as inheritance from parents (since the fall of the socialist government in the early 1990s) (n = 520). The female sample included all ever-married women (n = 1,166). In each case, separate models explored effects of birth order and family size (model 1), and sibling configuration (number of older brothers, younger brothers, older sisters, younger sisters) (model 2). A summary of results are presented in Table 1 and full models presented in Tables S2 and S3. All statistical analyses [generalized linear models (GLM) and logistic regression models (LOG REG)] were performed using SPSS version 14.

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