# Effects of the sex ratio and socioeconomic deprivation on male mortality

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Abstract

(a) Objective. We explored relationships between male mortality and the sex ratio. (b) Methods. We tested relationships across 142 societies and in longitudinal data from Scotland. (c) Results. A male-biased sex ratio was associated with reduced mortality by intentional self-harm across 142 societies. This was replicated in longitudinal Scottish data, and men were less likely to die by suicide and assault when there were more men in the population only when levels of unemployment were low. (d) Conclusion. We argue that this is consistent with a theoretical model in which men increase investment in relationships and offspring as 'competition' under a male-biased sex ratio, and that the conflicting results of previous work may stem from divergent effects of the sex ratio on mortality depending upon relative deprivation.

Keywords: sex ratio; mortality; longevity; sexual selection; risk-taking; sex roles.

## Introduction

Women live longer than men worldwide (Austad, 2001). Proximate level explanations include endocrinological and behavioral sex differences, such as testosterone-linked risk-taking in men (Maklakov & Lummaa, 2013) and a stronger tendency for women to seek help and support (Tamres, Janicki, & Helgeson, 2002). At an ultimate level, life history theory (e.g. Stearns, 1992) can be used as a theoretical framework for understanding variation in lifespan. Here, both the sex difference in mortality and its proximate underpinnings may stem from sex-specific solutions to the problem of investment of finite somatic resources in the competing demands of reproduction, growth, and survival (Archer et al., 2012; Clutton-Brock & Isvaran 2007; Daly & Wilson 1988; Liker et al., 2013).

Traditional parental investment theory (Trivers, 1972) proposes 'caring' and 'competitive' sex roles in which the sex who invests more at minimum in reproduction benefits from continuing to invest in offspring, whereas the sex who invests less benefits from investing in competing for additional mates. Thus, some portion of the sex difference in longevity may be due to reduced lifespan in males as a result of injury via direct competition for access to mates, or investment in costly traits and displays which increase the risk of predation and parasitism (Clutton-Brock & Isvaran, 2007; Kruger & Nesse, 2006; Moore & Wilson, 2002; Nussey et al., 2009; Promislow, 1992).

That the size of the sex difference in human mortality varies across populations (Gjonça et al. 2005) suggests that the strength of selection for male mating investment relative

to female investment in offspring is shaped by the local ecology. One ecological parameter which has received much attention in this context, is the local ratio of reproductively available males to females (the operational sex ratio; Emlen & Oring, 1977). Traditionally, competition has been predicted to be highest in the sex that is more common and/or with the higher potential reproductive rate (Clutton Brock & Vincent, 1991; Noë, Van Hooff, & Hammerstein, 2001). We would predict, then, a high sex ratio (i.e. 'male-biased' or relatively more males than females) to result in greater male investment in mating effort via competition for access to females (Clutton Brock & Parker, 1992; Clutton Brock & Vincent, 1991; Kvarnemo & Forsgren, 2000), resulting in increased male mortality by risk-taking and aggression (Kruger & Nesse, 2006). More recently, however, this prediction has been challenged, as the operational sex ratio has been shown to predict the strength of sexual selection only when the potential to monopolize mates is strong (e.g. in species with a lekking mating system; Klug et al., 2010).

In opposition to the traditional parental investment model, Kokko & Jennions (2008) argue that parental investment may be favored in the sex that faces more intense competition for mates when, for example, it makes more sense to invest in reproduction and survival than in competing for additional matings (see also Fitz & Galliard, 2008; Kokko & Johnstone, 2002; Kokko & Monaghan, 2001; Simmons & Kvarnemo, 2006). Competing for access to additional, scarce, females, for example, may lead to lower reproductive success than investing in a single mate and her offspring (Kokko & Jennions, 2008). Indeed, in non-human species a high sex ratio has been found to be linked to increased paternal investment (Liker et al., 2013, 2014), and in humans men are more likely to be married (Schacht & Kramer, 2016) and faithful to their partner

(Adimora et al., 2013) under a high sex ratio. We could derive an alternative prediction, then, that a high sex ratio would result in lower male mortality due to competition for mates via investment in a single relationship.

Indeed, as suggested by the opposing predictions derived from parental investment theories, a high sex ratio has been shown to increase both caring and aggressive competitive behaviors in human populations (Barber, 2003, 2009; Kruger, 2013; Schacht, Rauch, & Borgerhoff Mulder, 2014). For example, rates of violent crimes – perhaps a proxy measure of aggressive competition for resources and mates – have been reported to be highest in those regions of India with relatively higher numbers of men to women (Oldenburg, 1992). This has been argued to stem from a surplus of the sex with naturally higher levels of testosterone-driven aggression (Hudson & den Boer, 2002). Conversely, violent crime has also been shown to increase under a low sex ratio which, in turn, has been suggested to reflect a complex network of pathways from relationship conflict, paternity uncertainty, and jealousy (Barber, 2000; Guttentag & Secord, 1983; see also Kruger & Schlemmer, 2009). In a systematic review, Schacht et al. (2014) support this complex picture and report positive, negative, and null associations between violent crime and the sex ratio.

To better understand seemingly contradictory findings, recent formulations of the link between the sex ratio and male-male competition have challenged the assumption that this competition takes the form of violent, aggressive competition resulting in greater male mortality (see Schacht et al., 2014 for a review). In humans, competition amongst men for partners takes diverse forms, including attempting to attract the opposite sex by demonstrating greater willingness and ability to invest financially (Pedersen, 1991;

Pollet & Nettle, 2008; see Schacht et al., 2014 for a review). Furthermore, a high sex ratio may give women increased 'bargaining power' in the mating market (Guttentag & Secord, 1992; Angrist, 2002; see also Baumeister & Vohs, 2004). When there are more women in the population, for example, individual women may find themselves less able to make demands of potential partners resulting in lower paternal investment and investment in relationships by men (Guttentag & Secord, 1983; Schmitt, 2005).

A further factor, well known for its relation to mortality, and which may contribute to the complexity of findings described above, is the likelihood of adoption of risk-taking behavioral strategies by individuals as a consequence of environmental harshness. That is, there is a positive relationship across polygynous vertebrates between extrinsic and intrinsic mortality (i.e. the age-specific risk of mortality that is equal across a population in the case of the former, and mortality due to investment in reproduction versus survival in the latter; Clutton-Brock & Isvaran, 2007; Stearns, 1992). Nettle (2010; see also Uggla & Mace, 2015), for example, argues that men and women living under socioeconomic deprivation have higher extrinsic mortality due to environmental contaminants and cross-generational health effects, so have a shorter future in which to reap the benefits of health behaviors, resulting in increased intrinsic mortality. Although there is evidence that the sex ratio is related to environmental harshness, such that there are fewer males in the population during, for example, economic deprivation (e.g. Catalano, 2003), little is known about whether socioeconomic deprivation interacts with the local sex ratio to influence risk-taking.

Here we sought to identify sources of variation in male mortality. Specifically, we tested whether mortality by causes likely to be associated with aggression and risk-taking

(accidents, suicide, and assaults) were associated with the sex ratio and socioeconomic deprivation. By testing for relationships in a cross-cultural sample (Study 1) and a longitudinal sample in a single region of Scotland (Study 2), we sought to test between opposing predictions about the effect of the sex ratio (i.e. that a male-biased sex ratio will result in both increased and decreased male mortality). Furthermore, in both studies we tested whether the sex ratio interacts with socioeconomic deprivation in order to better understand the complex and contradictory findings of previous research.

## Study 1

### Methods

#### *Mortality rates*

Numbers of male deaths (per 1000) for 2012 were extracted from the World Health Organization Department of Health Statistics and Information Systems webpages (http://www.who.int/healthinfo/en/). We took scores for 'Unintentional Injuries', 'Intentional Injuries: Self –harm', and 'Intentional Injuries: Interpersonal violence'. Data for India and China were excluded due to mortality rates that were above the mean + 3SDs. Mean rates of death per 1000 population by unintentional injury were 9 (SD = 15.07), by intentional self harm were 1.96 (SD = 4.3), and for interpersonal violence were 2.15 (SD = 6.07).

#### *Sex ratio*

Total male and female adult population sizes were extracted from the United Nations Statistics Division webpages (http://unstats.un.org/unsd/default.htm). The adult sex ratio was computed by dividing the number of men by the number of women. We excluded Qatar, United Arab Emirates, and Bahrain as their sex ratio was greater than the mean + 3 SDs. The mean sex ratio was 0.9878 (SD = 0.0728).

*Deprivation*

We took Human Development Index (HDI) scores from the United Nations Development Program 2014 Human Development Report (http://hdr.undp.org/en/data). The HDI is a composite score comprised of data on a nation's life expectancy, education, and per capita income. The mean HDI score was 0.69 (SD = 0.16).

*Analyses*

With outlier societies excluded, we analysed a sample of 142 societies. All mortality variables and the sex ratio were substantially positively skewed, so were log transformed. Data met all other parameters of normality. We tested for associations between sex ratio and HDI with mortality rates using multiple linear regression models. We included population size (in millions) in all models to control for the likely impact of population size on, for example, precision of the estimate of sex ratio. Therefore, we conducted 3 multiple linear regression models, each including population size, adult sex ratio, and HDI as predictor variables, and with male mortality rates by unintentional injury, intentional self harm, and interpersonal violence as dependent variables in turn.

We also conducted the same models including the interaction term of adult sex ratio and HDI, in order to determine whether this predicted any of the variance. Given the potential for spatial autocorrelation, meaning that neighboring countries are not statistically independent units, we conducted a second set of identical analyses in a subset of our societies grouped by 10 world regions (South Asia, Anglo, Arab, Germanic Europe, Latin Europe, Eastern Europe, Confucian Asia, Latin America, Sub-Saharan Africa, and Nordic Europe), following Fincher et al. (2008). These clusters have been developed using international-level data on cultural values and beliefs and have been cross-validated in a split sample (Gupta, Hanges, & Dorfman, 2002). We calculated the mean of the adult sex ratio, HDI, population size, and mortality rates, by each cause within each cluster and conducted analyses on these.

## Results

Table 1 about here

The sex ratio predicted only the rate of deaths by intentional self harm ($\beta$=-0.13, $p$ = 0.013). That is, in societies with relatively more men than women the rate of male deaths by self harm was lower. For full model results, see Table 1.

HDI predicted the rate of deaths by unintentional injury ($\beta$=-0.14, $p < 0.001$), and by intentional self harm ($\beta$=0.13, $p$ = 0.009). That is, in societies with a higher development index fewer men died by unintentional injury, but more died by intentional self harm. Inclusion of the sex ratio * HDI interaction term did not improve model fit in any of the analyses (all $p > 0.1$). For full model results, see Table 1.

In the subsample of 10 cultural clusters, all patterns of relationships remained but lost significance. For full model results see Table 2.

Table 2 about here.

## Discussion

Here we tested for relationships between the sex ratio and socioeconomic deprivation with mortality by causes that, we argue, may be associated with aggression and risk taking (i.e. unintentional injuries, intentional self harm, and interpersonal violence) across 142 world societies. In those with a relatively higher sex ratio, the rate of male deaths by intentional self harm was lower. Societies with a higher human development index reported fewer men dying by unintentional injury, but more men dying by intentional self harm. These results, however, were not replicated in the sub-sample of cultural clusters and, while this is perhaps not surprising given the small sample size, we therefore exercise caution in interpreting our results and offer the following as tentative interpretations of the results of the full sample, which we follow up in Study 2.

Men in societies with relatively more men than women were less likely to die by intentional self harm. While this is consistent with a theoretical model in which males compete for relatively scarce females by engaging in paternal investment and investment in relationships, rather than in competing via risk-taking or aggressive conflict, this interpretation was not supported by relationships between the sex ratio and rates of male deaths by unintentional injuries or interpersonal violence. Here we

have assumed that death by all 3 causes are linked to risk-taking and/or aggressive competition. It is possible that they result from a more complex web of causes, but validation of this is required. That is, death by unintentional injury, interpersonal violence and intentional self harm may not be related to risk-taking, but instead may reflect societal level pressures such as gender equality or resource inequality. Further research should seek to identify links between societal sex ratio and more direct measures of risk-taking. It is also important to note that our results conflict with those of Kuroki (2014) who found that the sex ratio and male suicide rates were positively correlated within a single society (Japan), which suggests that patterns within smaller geographical regions may differ from those across societies.

In support of previous findings, the rate of deaths by unintentional injury was higher in societies with lower development (Arroyave et al., 2014). Conversely, the rate of male deaths by intentional self harm was higher in societies with higher development. This supports a discrepancy in the literature between a positive association between deprivation and suicide rates within societies or over time (e.g. Faria et al., 2006, Hawton et al., 2001), but a negative association across societies (e.g. WHO Suicide Prevention, 2006). It is difficult to interpret this result without controlling for the network of ecological variables which are likely to be correlated to both societal development and suicide rates (e.g. climate and gender equality).

Limitations

Cross-cultural work such as this is limited by the statistical issue of spatial autocorrelation, as a higher degree of shared linguistic, historical, and geographical

influences is present between neighboring or closely located countries ('Galton's problem', see Pollet et al., 2014 for a discussion). We sought to address this by conducting our analyses in a subsample of the countries which could be grouped into 10 cultural clusters which control for degree of cultural relatedness. While patterns remained, all results lost significance. Furthermore, the rules used to code deaths by causes vary across countries (e.g. Reynders, Scheerder, & Van Audenhove, 2011). This means that there is likely to be noise in the data due to inconsistency in these rules.

Our findings are subject to the ecological fallacy as we have used aggregate, population-level measures (e.g. mortality rates, sex ratios, HDI) to infer effects on the behavior of individuals. As Pollet et al. (2014) argue, this means that any findings from aggregate level cross-cultural data may not be replicated in finer grained individual-level data from a smaller locality.

Finally, we note that the negative relationship between societal sex ratio and the rate of male deaths by intentional self harm can only be concluded to be *consistent* with a theoretical model in which males compete for relatively scarce females by engaging in paternal investment and investment in relationships, rather than in competing via risk-taking or aggressive conflict. We have not measured or modelled investment in parenting or relationships, or risk taking and aggressive conflict, nor are we able to conclude from these contemporary data that patterns of behavior reflect evolutionary pressures or adaptive conditional behavioral strategies. Therefore, we emphasise that our findings are at best consistent with the theoretical models we describe, and that in order to determine whether they are due to variation in investment in parenting and

relationships, further research is required to model individual differences in such investment in relation to, for example, risk taking, aggression, and self-harm.

In an attempt to address some of these issues, in Study 2 we tested predictions in a smaller geographical region (the Tayside region of Scotland) over time (1981-2015). Furthermore, we utilized an adult sex ratio likely to be closer to the operational sex ratio than that of the total adult population used in Study 1.

## Study 2

### Methods

#### *Mortality rates*

Annual numbers of male deaths by suicide, accident, and assault in the Tayside region of Scotland from 1981 to 2015 were provided by National Records of Scotland. Tayside is 1 of Scotland's 14 'Health Board' regions. It covers an area of 7500 square km, and has a population of ~390, 000 distributed across large rural areas and small cities and towns. Numbers of deaths were estimates based on deaths coded using ICD-10 classifications as 'intentional self-harm' or 'undetermined intent' for suicides, 'accidents', 'sequelae of transport accidents', and 'sequelae of other accidents' for accidents, and 'assaults' for assaults. Individual risk of death by each cause for each year of the study was calculated as the number of deaths divided by the male population size of Tayside for that year (Palmer et al. 2005). Male adult population estimates were extracted from online resources available at National Records Scotland

(http://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/population/population-estimates/mid-year-population-estimates/population-estimates-time-series-data). The mean risk of death by suicide was 0.000231 (SD = 0.000042), by assault was 0.0000173 (SD = 0.0000123), and by accidents was 0.00035 (SD = 0.000078).

*Sex ratios*

Mid-year estimates of numbers of men and women aged 15 – 39 in Tayside were downloaded from the Scottish Government's statistics website (http://www.gov.scot/Topics/Statistics/). The data were available in 5-year age brackets, and we selected counts from brackets 15-19 to 35-39 as those that allow estimation of the adult sex ratio. To calculate the sex ratio, we divided the male population by the female population for each year. The mean sex ratio was 0.9238 (SD = 0.01).

*Socioeconomic deprivation*

Data on job seeker's allowance for Scotland as a whole, from 1981-2015 were extracted from the Scottish Government's statistics website (http://www.gov.scot/Topics/Statistics/). This shows the number of people who claimed government benefits due to unemployment. Although there are more geographically fine-grained measures, there was no single measure that was used across the entire study time-frame. Mean percentage of the national Scottish population that was unemployed was 3.46 (SD = 1.6).

*Analyses*

We analyzed trends in risk of male mortality in Tayside over time using non-seasonal ARIMA (autoregressive integrated moving average models). ARIMA compares systematic trends over time with temporal autocorrelation of data, and filters out statistical noise. Specifically, we used ARMAX model comparison which compares time-series data with independent variables. Systematic trends are identified by running permutations of a model testing autoregression and linear correlations between random errors, identifying the model of best fit. We used the IBM SPSS 22 'forecast' function. We ran 3 models, one each with male risk of mortality by intentional self harm, accidental, and assaults and dependent variables. Independent variables in each were sex ratio and unemployment rates, and their interaction term. Data met all parameters of normality. For post-hoc analyses of significant trends, we used simple linear regression models to determine direction and strength of relationships. Here were used moving averages of dependent variables in order to smooth the data (span = 3 years).

Results

In the model with male risk of death by suicide as the dependent variable (stationary $R^2$ = 0.39, Ljung-Box q = 6.83), each of the 3 predictors were significant: sex ratio (t = -4.13, p = 0.003), unemployment (t = -3.25, p = 0.003), and sex ratio*unemployment (t = 3.23, p = 0.003). Post-hoc bivariate simple linear regression analyses revealed a negative, non-significant, relationship between the sex ratio and the male risk of death by suicide (β = -0.27, p = 0.144). The bivariate relationship between risk of male death by suicide and

unemployment was also negative and non-significant (β = -0.25, p = 0.168). Finally, to explore the significant interaction between sex ratio and unemployment, we tested bivariate relationships between sex ratio and risk of death by suicide in years above and below the median for unemployment. Here, there was a strong significant negative relationship between the sex ratio and risk of death by suicide in years during which unemployment was 'low' (β = -0.82, p < 0.001), and a strong positive relationship during years when employment was 'high' (β = 0.86, p < 0.001). See Figure 1.

Figure 1 about here

In the model with male risk of death by accident as the dependent variable (stationary $R^2$ = 0.63, Ljung-Box q = 17.57), the sex ratio did not significantly predict risk of death by accident (t = 1.31, p = 0.201). Unemployment (t = 2.5, p = 0.018), and sex ratio*unemployment (t = -2.47, p = 0.019) were both significant predictors. Post-hoc bivariate simple linear regression analyses revealed a strong significant positive relationship between unemployment and the male risk of death by accident (β = 083, p < 0.001). To explore the significant interaction between sex ratio and unemployment, we tested bivariate relationships between sex ratio and risk of death by accident in years above and below the median for unemployment. Here, there was a strong significant negative relationship between the sex ratio and risk of death by accident in years during which unemployment was 'low' (β = -0.69, p = 0.003), and a stronger significant negative relationship during years when employment was 'high' (β = -0.73, p = 0.002).

In the model with male risk of death by assault as the dependent variable (stationary $R^2$ = 0.2, Ljung-Box q = 14.02), each of the 3 predictors were significant: sex ratio (t = -2.59,

p = 0.015), unemployment (t = -2.16, p = 0.038), and sex ratio*unemployment (t = 2.15, p = 0.039). Post-hoc bivariate simple linear regression analyses revealed a negative, non-significant, relationship between the sex ratio and the male risk of death by assault (β = -0.003, p = 0.983). The bivariate relationship between risk of male death by assault and unemployment was negative and significant (β = -0.42, p = 0.017). Finally, to explore the significant interaction between sex ratio and unemployment, we tested bivariate relationships between sex ratio and risk of death by assault in years above and below the median for unemployment. Here, there was a significant negative relationship between the sex ratio and risk of death by assault in years during which unemployment was 'low' (β = -0.62, p = 0.011), and a significant positive relationship during years when employment was 'high' (β = 0.55, p = 0.035). See Figure 2.

Figure 2 about here.

## Discussion

Here we replicated the relationships between the sex ratio and deprivation on risk of mortality that we reported in Study 1 over a period of 35 years in a single region of Scotland. In both samples, the sex ratio was inversely related to male death by suicide/intentional self harm, and deprivation was positively related to risk or rates of male death by accident/unintentional injury and inversely with risk/rates of death by suicide/intentional self harm. That is, when deprivation is high, rates of male deaths by suicide are lower and rates of male deaths by accident are higher. When the sex ratio is high (i.e. male-biased), the rate of male death by suicide is lower. In addition, we found

the risk of male deaths by assault to be lower under a male-biased sex ratio and when unemployment was high.

In Study 1, we tentatively interpreted the negative relationship between the sex ratio and suicide rate as consistent with a theoretical model in which male competition occurs via investment in behaviors that support investment in romantic relationships and parenting, rather than risk-taking or aggressive conflict. We find further support for this interpretation in Study 2 as the sex ratio was also inversely related to the risk of male death by assault, suggesting lower rates of violence and aggressive conflict when there is more competition for access to females. Again, however, we urge caution in interpreting our results as evidence for greater investment in relationships and parenting, and lower investment in risk taking and aggression, under a high male sex ratio. While our findings are consistent with the patterns we might expect if this were the case, we have not measured such investment or behaviors and further research is required to do so.

Interestingly, we did not find similar patterns in risk or rates of death by accident/unintentional injury. Suicide and assault are both linked to violence (towards self and others, respectively), whereas accidental death may be more closely linked to risk taking. Perhaps a male-biased sex ratio results in reduced violence, but does not relate to risk-taking. In support of previous findings, and those of Study 1, the rate of deaths by accident was higher during years of high unemployment. That the risk of male deaths by suicide was lower during these years supports our suggestion that suicide and accidental deaths are predicted by different underlying psychology and resultant behaviour. As above, however, we recommend further research to explore the

associations we propose here between individual level aggression and risk taking and rates of deaths by accident, assault, and self harm.

We found interactions between the sex ratio and unemployment such that men were less likely to die by suicide and assault under a high than a low sex ratio when levels of unemployment in Tayside were low. However, when unemployment was high men were more likely to die by suicide and assault under a high sex ratio. One interpretation of this is that men living under a high sex ratio compete by attempting to provide financial resources for a partner and their children (Pollet & Nettle, 2008). During times of relative socioeconomic stability, this may reduce risk-taking behavior and deaths by suicide and assault. During times of relative deprivation, however, this may be a stressful and challenging strategy for men. They may struggle to attain the financial resources require to support a partner and, therefore, suffer emotional distress which, in turn, increases rates of deaths by suicide and assault. Alternatively, the lack of opportunity to provide for a partner may lead to a risk-taking strategy with increased risk of mortality. If this were the case, however, we may expect equivalent effects for risk of mortality by accidents. These findings suggest that the diverse effects of the sex ratio on crime and mortality rates reported in the literature (e.g. Hudson & den Boer, 2002; Oldenburg, 1992; Uggla & Mace, 2015) may arise from differences in the level of socioeconomic deprivation of the populations under investigation. As we have emphasized for all our findings, we can only suggest here that the patterns of our results are consistent with the interpretations we describe and further research is required to model relationships between individual-level risk taking, stress, distress, and population level sex ratio and deprivation.

Here we have shown that a male-biased sex ratio was associated with reduced mortality by intentional self-harm across 142 societies. This was replicated in longitudinal data from a single region of Scotland, although men were less likely to die by suicide when there were more men in the population only when levels of unemployment were low. These findings contribute to the literature on predicting times and places of higher population-level suicide risk and are therefore of relevance to those interested in public health and the epidemiology of suicide risk. They also suggest potential individual-level risk factors which, through further exploration, may contribute to our ability to more accurately assess or formulate suicide risk in clinical practice.

## Limitations

Here we have treated death by unintentional injury, intentional self harm, and violence as proxies of risk taking at the population level. We acknowledge that further research is required to confirm this link by, for example, testing for associations between individual measures of risk taking in societies that differ in mortality by unintentional injury, intentional self harm, and violence. It is also possible that the sex ratio is linked to further socioecological variables such as gender equality, and further research could elicit these links.

We have sought to balance the relative strengths and weaknesses of a cross cultural analysis with a longitudinal analysis from a single region. As we acknowledged above, cross-cultural methods such as those employed in Study 1 are prone to issues of spatial autocorrelation. Therefore, in Study 2 we tested predictions in a single geographical region over time. While this avoids spatial autocorrelation, it is of course limited by

telling us only about patterns in a single unique population. We hope that by triangulating findings via these 2 methods we allow greater confidence in our findings.

## Conclusions

To summarise, we report negative relationships between the sex ratio and male rates of death by suicide and between a national index of development and deaths by unintentional injuries, and a positive relationship between development and male deaths by suicide across a sample of 142 world societies. These results were replicated in a longitudinal study of single region of Scotland. In Study 2, we found interactions between the sex ratio and socioeconomic deprivation, such that men were less likely to die by suicide and assault under a high sex ratio when levels of unemployment were low. However, when unemployment was high men were more likely to die by suicide and assault under a high sex ratio. We interpreted this as being consistent with a male strategy to compete for partners by seeking to provide for them and their children, which imposes stress during times of socioeconomic deprivation. However, we acknowledge that further research which models individual level strategies in relation to self harm, risk taking, and aggression, is required to determine whether our tentative conclusions around proximate mechanisms have validity.

Our results challenge the dogma that a preponderance of males results in increased violence. They raise questions, however, concerning the ways in which local sex ratios translate into behaviors which reduce mortality by risk-taking and aggression, and we argue that such effects depend upon local socioeconomic conditions. It is possible, for example, that a scarcity of potential opposite sex partners of either sex shapes the

dynamics and expectations of relationships which, in turn, influences a multitude of attitudes and behaviors. Indeed, the sex ratio and the allocation of men and women to gendered social roles are likely to be closely linked. Future work should seek to test relationships between gender equality, sex ratio, and mortality rates, as well as to better understand the links between risk-taking and mortality by suicide, accidents and violence.

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Table 1 Results of linear regression models testing predictors of rates of male deaths across 142 world societies.

| Dependent variable | Adj-$R^2$ | F(3,139) | Predictor | β |
|---|---|---|---|---|
| Male unintentional injury | 0.81*** | 200.27 | Sex ratio | -0.04 |
| | | | HDI | -0.14*** |
| | | | Population size | 0.89*** |
| Male intentional self harm | 0.59*** | 70.18 | Sex ratio | -0.13* |
| | | | HDI | 0.15** |

| | | | | |
|---|---|---|---|---|
| | | | Population size | 0.75*** |
| Male interpersonal violence | 0.31*** | 22.01 | Sex ratio | -0.03 |
| | | | HDI | -0.08 |
| | | | Population size | 0.56*** |

* p < 0.05; ** p < 0.005; *** p < 0.001

Table 2 Results of linear regression models testing predictors of rates of deaths across 10 cultural clusters.

| Dependent variable | Adj-$R^2$ | F(3,7) | Predictor | β |
|---|---|---|---|---|
| Male unintentional injury | 0.81** | 200.27 | Sex ratio | -0.27 |
| | | | HDI | -0.33 |
| | | | Population size | 0.99*** |
| Male intentional self harm | 0.34 | 2.73 | Sex ratio | -0.22 |
| | | | HDI | 0.39 |

| | | | | |
|---|---|---|---|---|
| | | | Populatio n size | 0.49 |
| Male interpersonal violence | < 0.01 | 0.9 | Sex ratio | -0.31 |
| | | | HDI | -0.45 |
| | | | Populatio n size | 0.45 |
| | | | HDI | -0.5 |

* p < 0.05; ** p < 0.005; *** p < 0.001

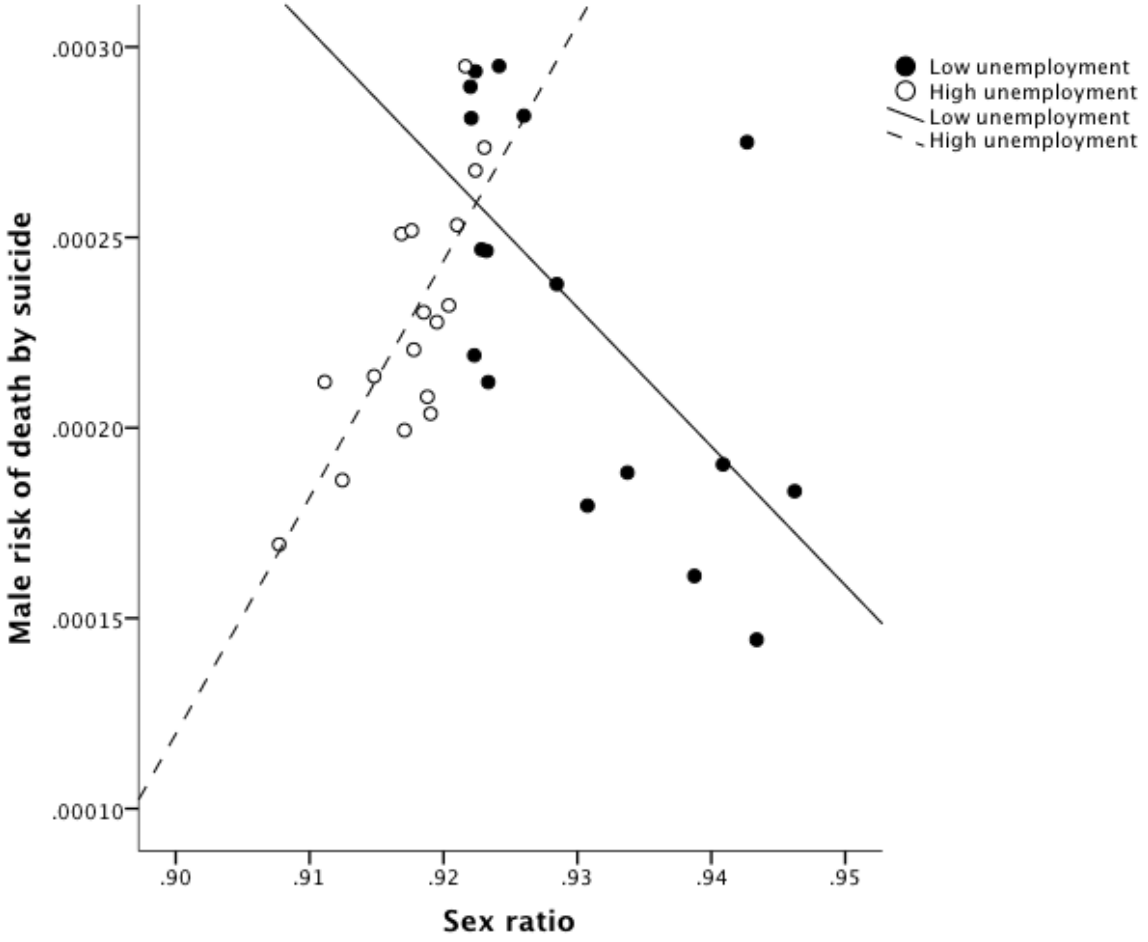


Figure 1 Relationships between sex ratio and risk of male suicide under high and low unemployment.

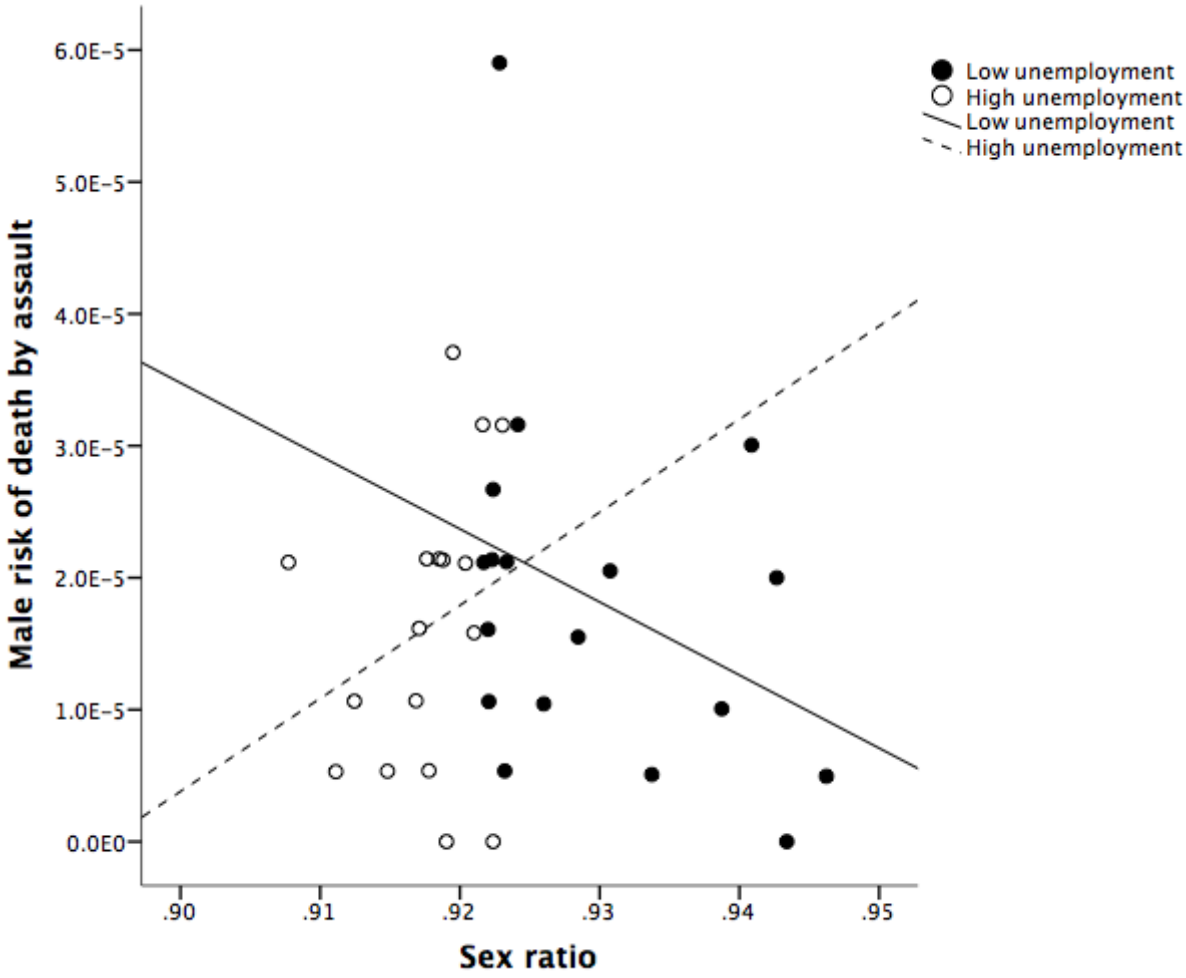


Figure 2 Relationships between sex ratio and risk of male death by assault under high and low unemployment.