

# Sex- and age-specific relations between economic development, economic inequality and homicide rates in people aged 0–24 years: a cross-sectional analysis

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**Objective** To test whether relations between economic development, economic inequality, and child and youth homicide rates are sex- and age-specific, and whether a country's wealth modifies the impact of economic inequality on homicide rates.

**Methods** Outcome variables were homicide rates around 1994 in males and females in the age ranges 0–4, 5–9, 10–14, 15–19 and 20–24 years from 61 countries. Predictor variables were per capita gross domestic product (GDP), GINI coefficient, percentage change in per capita gross national product (GNP) and female economic activity as a percentage of male economic activity. Relations were analysed by ordinary least squares regression.

**Findings** All predictors explained significant variances in homicide rates in those aged 15–24. Associations were stronger for males than females and weak for children aged 0–9. Models that included female economic inequality and percentage change in GNP increased the effect in children aged 0–9 and the explained variance in females aged 20–24. For children aged 0–4, country clustering by income increased the explained variance for both sexes. For males aged 15–24, the association with economic inequality was strong in countries with low incomes and weak in those with high incomes.

**Conclusion** Relations between economic factors and child and youth homicide rates varied with age and sex. Interventions to target economic factors would have the strongest impact on rates of homicide in young adults and late adolescent males. In societies with high economic inequality, redistributing wealth without increasing per capita GDP would reduce homicide rates less than redistributions linked with overall economic development.

**Keywords** Homicide/economics; Violence/economics; Socioeconomic factors; Economics; Economic development; Sex factors; Age factors; Income; Cross-sectional studies (*source: MeSH, NLM*).

**Mots clés** Homicide/économie; Violence/économie; Facteur socioéconomique; Économie; Développement économique; Facteur sexuel; Facteur âge; Revenu; Etude section efficace (*source: MeSH, INSERM*).

**Palabras clave** Homicidio/economía; Violencia/economía; Factores socioeconómicos; Economía; Desarrollo económico; Factores sexuales; Factores de edad; Renta; Estudios transversales (*fuentes: DeCS, BIREME*).

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Voir page 803 le résumé en français. En la página 803 figura un resumen en español.

## Introduction

Violence is “the intentional use of physical force or power, threatened or actual, against another person or against oneself or a group of people, that results in or has a high likelihood of resulting in injury, death, psychological harm, ‘maldevelopment’ or deprivation” (1). Interpersonal violence — the focus of this paper — is violence between individuals for which there is no clearly defined political motive.

Male and female youths aged 15–24 years are the primary victims and perpetrators of interpersonal violence in many world regions (2, 3), and youth violence is a growing contributor to the global disease burden (4). It is important, therefore, to examine whether economic factors affect the rate at which males and females aged 0–24 years are murdered (the homicide rate). This age range includes the late adolescent and early adult periods (during which homicide rates are highest), the age groups for which the risk of homicide is lowest (5–9 and 10–14 years) and the 0–4-year age group, in which the homicide rate is higher than

in children aged 5–14 and during which the child's early development shapes later risk for violence (5–9). An understanding of how economic factors vary with homicide rates across these age groups provides insight into the mechanisms that underlie associations between economic development, income distribution and overall mortality (10–12).

International studies that included economic indicators in models of sex- and age-specific homicide rates focused on infants (0–12 months) and children up to 14 years (5, 6). Most other studies used rates aggregated for both sexes and for all ages. For economic development measures, these studies show contradictory results — most indicate higher homicide rates in countries with lower per capita gross domestic products (GDPs) (13–16), but others show no clear relation (17–19). Findings on the association between homicide and economic inequality within countries are less ambiguous; they consistently show that high levels of inequality coincide with high homicide rates (16, 19, 20–24).

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This paper aims to explain how economic factors relate to rates of homicide in infants through to young adults. It describes the results of a cross-sectional ecological study of the relation between per capita income, intrasocial and sex-related inequalities in income distribution, and homicide rates in males and females aged 0–24 years. We aimed to model the sex- and age-specific relations between indicators of economic development, economic inequality and homicide rates, and to examine how these relations are modified by the economic status of countries.

We considered including other factors, such as type of political system, social cohesion and attitudes toward violence, in the analysis (25). Unfortunately, indicators of these factors were available for too few of the study countries to be included.

### Theoretical considerations

Examination of the risk factors, risk behaviours and situational determinants shown to be associated with youth violence (3) suggests that long-term influences (biological, psychological, family, peer and community) produce stable differences between individuals in their potential for committing violence — the “violence potential”. Transient factors that could motivate an individual to be violent, such as anger or drunkenness, contribute towards short-term within-individual variations in violence potential. Situational opportunities that affect the likelihood of a youth motivated towards committing violence encountering a suitable victim in the absence of a capable guardian (26) interact with individual-level factors to determine whether the violence potential converts into actual violence. Economic development and inequality influence these different factors through a mixture of indirect and direct pathways that changes with sex and age.

In people aged 15–19 and 20–24 years, homicide rates in both sexes across all economic levels are high because of biological and psychosocial changes that occur at these ages. The increases in rates after age 15 are magnified in impoverished societies and those with high financial inequalities because of the intersection between the direct influences of economic disadvantage and the delayed effects of such disadvantage on the long-term violence potential of individuals. Economic deprivation and inequality increase individuals’ frustrations, anger and perceived needs; this increases their short-term potential for committing violent acts that express their emotions and “rational” violent acts that bring them gains through criminal means. The high prevalence of violence within societies that are economically disadvantaged or that have high levels of economic inequality reduces social barriers to violence; this means that populations in such countries have larger proportions of individuals with high long-term violence potentials. The association between homicide rates and economic factors should therefore be highest in those aged 20–24 years.

Homicides of infants and young children are most often committed by their parents, step-parents or other caregivers (27). Parents or caregivers who are economically deprived are less likely to have control over factors such as pregnancy, birth spacing and their own lives, which makes them more likely to view infants and young children as strains on their household’s financial and emotional economy. Homicides in children aged 0–9 years should be expected, therefore, to increase with increasing economic deprivation and inequality.

At a societal level, overall wealth is predicted to modify the impact of economic inequalities on homicide rates. Factors such as percentage spent on social welfare and child support, social capital, employment patterns and the built environment are all expected to influence the impact of economic inequality. The strength of the association between homicide rates and economic inequality should be greatest in poor countries with high inequality.

## Methods

### Population data and homicide counts

We defined homicides as deaths coded as International Classification of Diseases (ICD)-9 codes E960–969 and ICD-10 codes X85–Y09. We obtained homicide counts and population data for males and females aged 0–4, 5–9, 10–14, 15–19 and 20–24 years from the World Health Organization (WHO).

WHO receives mortality data collected by civil authorities from member states. For the study countries (Table 1), the percentage registration cover for deaths due to all causes in both sexes and all age groups combined varied from just over 50% in one developing country through 70–90% for the remaining developing countries to 100% for most of the developed countries (28). Coding inaccuracy was indexed with the proportion of all deaths from injury coded as “injury undetermined whether accidentally or purposely inflicted” (ICD-9 E980–E989; ICD-10 Y10–Y34). The inaccuracy ranged from around 3% in most developed countries to over 40% in one developing country; in most developing countries it was 5–10%. More detailed information on the coverage of death registration by sex-, age- and cause-specific groupings and the proportion of homicides among deaths classified as manner undetermined was unavailable; we considered, therefore, that it was inappropriate to use these undifferentiated measures as correction factors.

We set the base year at 1994 to maximize the number of study countries included. We excluded countries with populations <1 million and those with <3 years of data between 1992 and 1996 to reduce errors in rate calculations; this left 61 countries. For each age and sex group, a one-year average homicide rate per 100 000 population was calculated with data for 1994 plus the two closest consecutive years. For the group aged 0–24, age-standardized rates were calculated with the standard world population for 1994 (28).

### Economic development and inequality measures

We used two development indicators and three inequality measures as economic variables. The first development indicator was “real gross domestic product (GDP) per capita (PPP\$)” (hereafter “per capita GDP”), which is defined as “the GDP per capita of a country converted into US dollars on the basis of the purchasing power parity exchange rate” (29). This measure is adjusted for differences in purchasing power to correct for the fact that non-tradable services are cheaper in poorer countries than in rich countries; this means that the gap in living standards is actually smaller than suggested by comparisons at current exchange rates. Data for 1995 were obtained for all 61 countries (30).

The second development indicator was the average annual percentage change in gross national product (GNP) per capita for 1985–95 (hereafter “change in GNP”). This has

Table 1. Homicide rates in people aged 0–24 years from 61 study countries grouped by age-standardized, one-year homicide rates per 100 000 population around 1994<sup>a</sup>

Country	Median (range, SD) homicide rate
<b>High violence <math>\geq 10</math></b> Armenia, Azerbaijan, Brazil, Colombia, Russian Federation and Venezuela	13.63 (10.46–55.91, 17.66)
<b>Medium violence 3–9.99</b> Albania, Belarus, Cuba, Ecuador, Estonia, Kazakstan, Latvia, Lithuania, Mexico, Nicaragua, Republic of Moldova, Tajikistan, Ukraine and United States of America	5.10 (3.34–9.93, 2.32)
<b>Low violence 1–2.99</b> Argentina, Australia, Belgium, Bulgaria, Canada, Chile, China, Costa Rica, Croatia, Czech Republic, Finland, Hungary, Italy, Kyrgyzstan, New Zealand, Romania, Singapore, Slovenia, Switzerland, Thailand, Turkmenistan and Uzbekistan	1.57 (1.00–2.96, 0.58)
<b>Very low violence <math>\leq 0.99</math></b> Austria, Denmark, France, Germany, Greece, Hong Kong Special Administrative Region of China, Ireland, Israel, Italy, Japan, Netherlands, Norway, Poland, Portugal, Republic of Korea, Slovak Republic, Spain, Sweden and United Kingdom of Great Britain and Northern Ireland	0.80 (0.36–0.98, 0.19)

<sup>a</sup> Homicide rates were calculated with data transmitted to the World Health Organization by the competent authorities of the countries concerned.

negative values when populations are becoming poorer and positive values when populations are becoming wealthier; this data was available for 43 countries (30).

The first indicator of economic inequality was the GINI coefficient. This measures the income gap between the rich and the poor within a country, and it indexes “the extent to which the distribution of income ... among individuals or households within an economy deviates from a perfectly equal distribution” (29). The coefficient ranges from 0 (perfect equality) to 100 (perfect inequality). We used data for 1995, or the closest available years, with a low cut-off year of 1988 (31, 32). Some coefficients reflected expenditure rather than income: we calibrated the former to the income-based data by adding 6.6 (the average difference between expenditure- and income-based coefficients) (31). Coefficients were available for 54 countries.

The second inequality measure was percentage share of income, which indicates the income share accruing to subgroups of the population separated into fifths. Data for 1995 (or the closest available year) (31) were available for 44 countries.

The third inequality measure — the rate of female economic activity as a percentage of male economic activity — was an index of sex-related economic inequality. This indicates the percentage of women with access to paid jobs relative to men; data for 1995 were available for all 61 countries (30).

### Statistical analyses

Homicide rates contained potential upper univariate outliers (Armenia, Azerbaijan, Brazil, Colombia, the Russian Federation and Venezuela) and the natural logarithm (ln) was used to

lessen the impact of extreme values for these countries. We assumed that the difference in rates made by each dollar of GDP would be greater in countries with low per capita GDPs than in those with high per capita GDPs. We used the natural logarithm of per capita GDP because it measures the proportional difference between countries rather than the absolute difference. The relation between female economic activity rate and homicide rate was curvilinear, so we used the measure in its simple and squared forms. The GINI coefficient and change in GNP data were used unchanged.

We tested for outliers for variables other than homicide rate with computations of the interquartile range (33). This indicated five potential univariate outliers for change in GNP (upper outliers: China, Republic of Korea, Singapore and Thailand; lower outlier: Armenia). Two countries were potential outliers for more than one measure — the United States of America was an outlier with a high homicide rate and high per capita GDP, and Armenia was an outlier with a large negative change in GNP and a low female homicide rate. We conducted analyses with and without the potential outliers.

The first analysis examined the predictor variables for colinearity. The association between the five economic measures and age- and sex-specific homicide rates were then modelled (Annex) by adding each variable in turn to a regression equation. We excluded the five measures of income by population fifths from the modelling procedure, but we used them to test the effects of different income distributions on the final model.

We ran the full model on groups of countries with per capita GDPs  $\geq$  US\$ 12 000 and  $\leq$  US\$ 11 999 to test the hypothesis that the relation between inequality and homicide is greater in poor countries than in rich countries. The dataset included 23 ex-Soviet transition societies. We stratified the sample into transition and non-transition countries to examine the effect of including these countries.

## Results

We grouped the study countries into four arbitrarily defined levels of violence by age-standardized homicide rates among 0–24 year olds (Table 1). High-violence countries ( $\geq 10$  homicides per 100 000) were mainly low- to middle-income Latin American, Eastern European and ex-Soviet countries. Two countries in this group (Armenia and Azerbaijan) were at war when the data were collected, and some of the deaths classified as homicides could have been war related. Medium-violence countries (3–9.99 homicides per 100 000) were low- to middle-income ex-Soviet, central and east European countries, except for Cuba, Mexico and the United States of America. Low-violence countries (1–2.99 homicides per 100 000) included low-, middle- and high-income countries from different regions. Very low-violence countries ( $\leq 0.99$  homicides per 100 000) were high-income western European countries, except for Israel, Hong Kong Special Administrative Region of China, Japan, the Democratic People’s Republic of Korea and the Slovak Republic.

### Inter-relations between the economic variables

The Pearson correlation coefficients ( $r$ ) between the economic predictor variables showed that per capita GDP and GINI had a low negative correlation (Table 2); this indicated a weak tendency for wealthier societies to have lower overall income inequalities. The GINI coefficient correlated highly with the

Table 2. Intercorrelations, means and standard deviations among economic predictors of homicide rates in high-, low- and middle-income countries, around 1994

Predictors	Variable number	1	2	3	4	5	6	7	8	9
Gross domestic product per capita (\$PPP)	1	NA	0.31	-0.34	0.29	0.41	-0.41	0.29	-0.42	-0.22
Change in gross national product (%)	2		NA	-0.08	0.20	0.12	0.08	0.09	-0.10	-0.10
GINI coefficient	3			NA	-0.90	-0.97	-0.97	-0.70	0.98	-0.52
Income group <sup>a</sup>										
Poorest fifth	4				NA	0.96	0.89	0.56	-0.94	0.39
Second fifth	5					NA	0.97	0.68	-0.98	0.53
Middle fifth	6						NA	0.77	-0.99	0.52
Fourth fifth	7							NA	0.74	0.47
Richest fifth	8								NA	-0.51
Female economic activity	9									NA
No of observations		61	43	55	53	45	45	45	45	61
Mean (SD)		11 022 (8100)	1.27 (2.69)	36.83 (9.88)	6.87 (2.72)	11.71 (2.53)	15.90 (2.27)	21.74 (1.65)	43.44 (8.30)	74.12 (16.51)

<sup>a</sup> Percentage share of income.  
NA = not applicable.

percentage share of income by population fifths — it had an almost perfect positive correlation with the amount of income held by the richest fifth of populations and high negative associations with the poorest (first) fifth of populations through to the fourth fifth. Change in GNP was weakly associated with all other predictor variables.

The rate of female economic activity had a strong negative correlation with the GINI coefficient and with the percentage of income held by the richest fifth of the country populations, and it had modest positive correlations with the income share in the first to fourth fifths. This means that women in countries with lower overall economic inequality tend to have better access to salaried employment.

### Sex- and age-specific effects

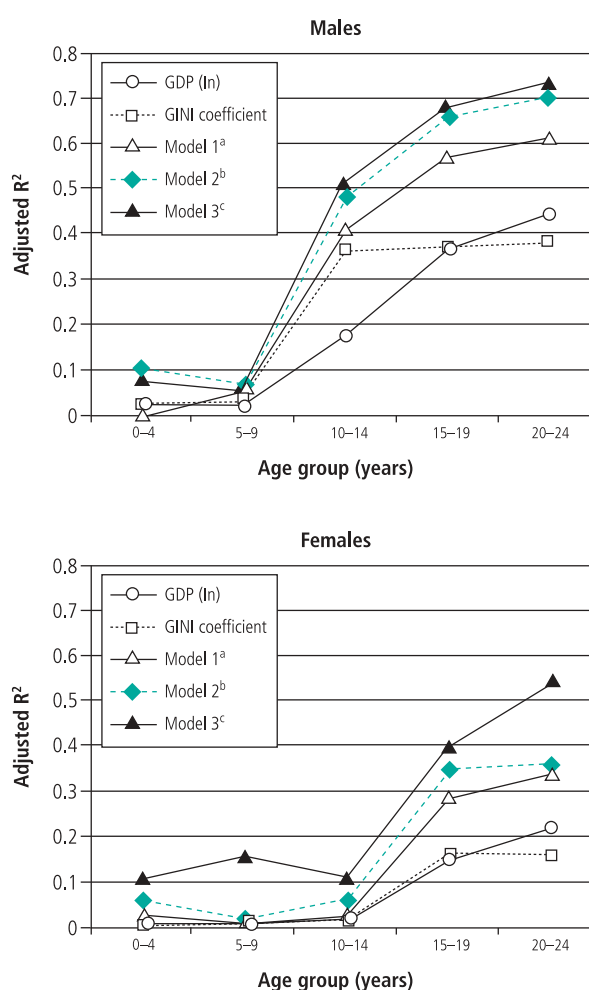
Table 3 reports the results for the sex- and age-specific effects of per capita GDP (ln), GINI coefficient and three multivariate regressions for the logarithm of homicide rates by sex and age. Fig. 1 shows the explained variance for each sex group and age group.

The first monivariate regression was of per capita GDP (ln) — this had a negligible association with variations in homicide rates in the two youngest age groups. For males, the association was much stronger from age 10–14 upwards. For females, an increase in strength of association was first seen in the age range 15–19. For both sexes, this association was negative — this meant that lower homicide rates were associated with higher per capita GDP.

The second regression examined the GINI coefficient. For both sexes, the relation with homicide rates in the age ranges 15–19 and 20–24 years was significantly positive, whereas in the age range 10–14 years it was significantly positive for males only. As for per capita GDP (ln), the GINI coefficient had only a weak relation with homicide rates in the youngest age groups of both sexes (Table 3).

Model 1 combined per capita GDP (ln) and GINI coefficient. In males and females in the youngest three age groups, model 1 explained an almost identical amount of variance as the GINI coefficient (Fig. 1). In groups of people

Fig. 1. Relation between economic factors, age and homicide rates in males and females between 1992 and 1996



<sup>a</sup> GDP (ln) and GINI coefficient.

<sup>b</sup> GDP (ln), GINI and change in gross domestic product (GDP).

<sup>c</sup> GDP (ln), GINI, change in GDP, female economic activity and (female economic activity)<sup>2</sup>.

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Table 3. Sex- and age-specific effects (explained variance (adjusted  $R^2$ )) of per capita gross domestic product (GDP), GINI coefficient and three multivariable models on the logarithm of homicide rates

Variable	Age (years)									
	0–4		5–9		10–14		15–19		20–24	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Per capita GDP (ln)	-0.02	-0.01	-0.02	-0.005	-0.17 <sup>d</sup>	-0.02	-0.37 <sup>d</sup>	-0.15 <sup>d</sup>	-0.44 <sup>d</sup>	-0.22 <sup>d</sup>
GINI coefficient	0.02	0.01	0.03	0.02	0.36 <sup>d</sup>	0.01	0.37 <sup>d</sup>	0.16 <sup>e</sup>	0.38 <sup>d</sup>	0.16 <sup>d</sup>
Model										
1 <sup>a</sup>	0.00	0.03	0.05	0.01	0.41 <sup>d</sup>	0.03	0.57 <sup>d</sup>	0.29 <sup>d</sup>	0.61 <sup>d</sup>	0.34 <sup>d</sup>
2 <sup>b</sup>	0.10	0.06	0.06	0.02	0.48 <sup>d</sup>	0.06	0.66 <sup>d</sup>	0.35 <sup>d</sup>	0.70 <sup>d</sup>	0.36 <sup>d</sup>
3 <sup>c</sup>	0.08	0.11	0.05	0.16 <sup>f</sup>	0.51 <sup>d</sup>	0.11	0.68 <sup>d</sup>	0.40 <sup>d</sup>	0.73 <sup>d</sup>	0.54 <sup>d</sup>

<sup>a</sup> GDP (ln) and GINI coefficient.

<sup>b</sup> GDP (ln), GINI and change in gross domestic product (GDP).

<sup>c</sup> GDP (ln), GINI, change in GDP, female economic activity and (female economic activity)<sup>2</sup>.

<sup>d</sup>  $P < 0.0001$ .

<sup>e</sup>  $P < 0.01$ .

<sup>f</sup>  $P < 0.05$ .

aged 15–19 and 20–24, the combination of per capita GDP and GINI dramatically increased the explained variance for males and females.

Model 2 added change in GNP to the regression. This increased the explained variance strongly for boys aged 0–4, but only modestly for the three oldest age groups and had no meaningful impact on boys aged 5–9 years. Similar results were seen for females.

Model 3 added female economic activity into the equation. In females, this sharply increased the amount of explained variance among children aged 0–4 and 5–9 and adults aged 20–24. In males, it modestly increased the association with homicide rates only among boys aged 0–4 years.

We also replaced the GINI coefficient with percentage share of income for the poorest through to the richest population fifths in turn. The association was strongest for males and females in the regression with the percentage share of income held by the richest fifth and weakest with the percentage share of income in the fourth fifth.

Table 4 shows the explained variance (for model 3), with and without the outliers, for males and females aged 0–24. When the five potential outlying countries for change in GNP were excluded, the explained variance for male homicide rates increased by 1 percentage points. For females only, exclusion of these same five countries increased the explained variance by 17 percentage points; this was mainly because of the inclusion of Armenia. When the United States of America was excluded, the explained variance increased by 3 percentage points for males, but this exclusion had no appreciable effect for females.

### Effects of economic development status of a country

The final hypothesis we tested was that the association between economic inequality and homicide rates would be weak in societies with high levels of economic development. We used per capita GDP as a measure of economic development to group countries into those with per capita GDP  $\geq$  US\$ 12 000 and  $\leq$  US\$ 11 999. Fig. 2 shows the association between economic factors and homicide rates in males and females at different ages for the two GDP-based clusters of countries. The main effects of this GDP-based clustering were on homicide rates in those of both sexes aged

Table 4. Explained variance (adjusted  $R^2$ ) with and without potential outliers for all explanatory variables included (model 3) in people aged 0–24

	Males	Females	All
All countries included	0.72	0.44	0.69
Excluded			
USA	0.75	0.43	0.72
Armenia	0.69	0.54	0.67
China, Republic of Korea, Singapore, Thailand and Armenia	0.73	0.61	0.71
China, Republic of Korea, Singapore, Thailand, Armenia and USA	0.77	0.61	0.74

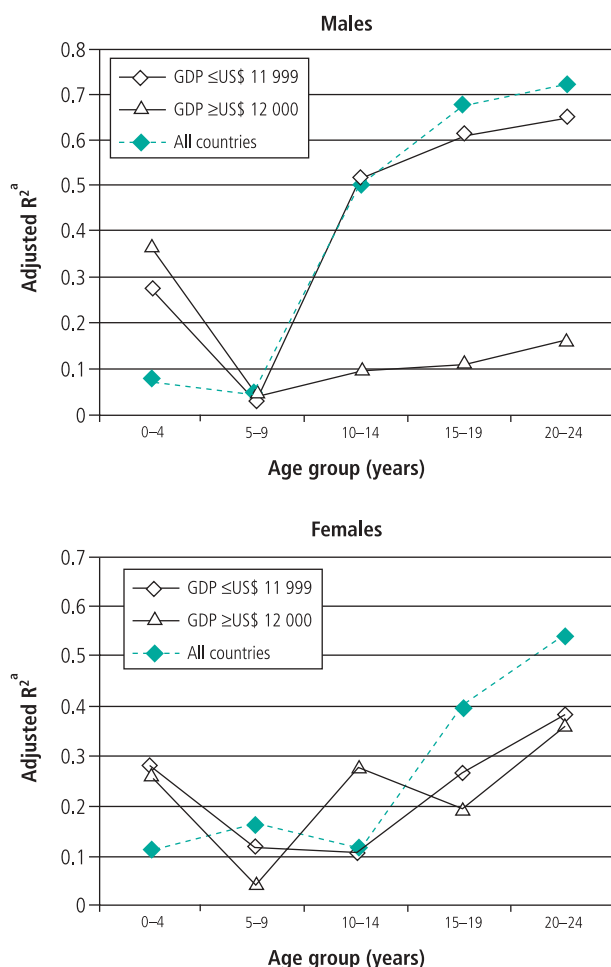
0–4 and on male homicides among 15–24-year olds. For rates among 0–4-year olds, country clustering by income substantially increased the amount of explained variance (adjusted  $R^2$  increased from just over 0.10 to around 0.30) for both sexes in both clusters. For rates in males aged 15–24, the association with economic inequalities remained strong (adjusted  $R^2$  0.60–0.70) in the cluster of lower-income countries, but it was dramatically weaker (0.10–0.20) in the cluster of higher-income countries. For females aged 15–24, only slight differences were seen in the strength of the association between homicide rates and economic inequalities between lower- and higher-income countries.

To test the effect of the 23 ex-Soviet transition societies, we used the overall homicide rate for those aged 0–24. Each step of the model remained significant for both subsamples. Perhaps unsurprisingly, the model including change in GNP showed the greatest differences — 0.60 for the variance in non-transition countries and 0.82 for transition countries.

### Discussion

Economic development, economic inequality and homicide rates in children and youths have complex relations that are strongly mediated by the victim's sex and age. This complexity has been masked by results of studies that aggregated outcome data by all ages and both sexes, and by studies that combined data on income inequality for countries with different overall income levels.

Fig. 2. Association between child and youth homicide rates, inequality and economic development in countries with GDP ≤US\$ 11 999, countries with GDP ≥US\$ 12 000 and all countries



<sup>a</sup>Adjusted R<sup>2</sup> refers to the amount of variance in homicide rates explained by Model 3: GDP (ln), GINI, change in GDP, female economic activity and (female economic activity)<sup>2</sup>.

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As expected, the strongest relation between economic measures and homicide rates was seen in males aged 20–24 years. Also as expected, analyses that clustered countries into higher- and lower-income groups showed that the relation was weaker for countries with greater overall wealth. By contrast, grouping countries by income had little effect on the relation between economic measures and rates of homicide in females aged 20–24; this suggests that homicides in this group are driven, in part, by different dynamics to those that drive homicides in young adult males. Female economic inequality had its own distinctive role — it increased the association between economic measures and homicide rates in females aged 0–4, 5–9 and 20–24, but it had a limited effect on males that was seen only in boys aged 0–4.

For boys aged 0–4, a weak relation was seen between the economic variables and homicide rates in analyses conducted for all countries together. This relation was much stronger for males and for females when the countries were split into higher- and lower-income clusters and was equally strong in both income groups. Although this confirms the prediction that homicide rates in infants would be higher in more

economically unequal societies, it is difficult to understand why greater overall wealth did not moderate the strength of the relation. The observed relation suggests that homicides of infants and young children are partly caused by risk factors independent of overall societal wealth — such as the psychopathology of individuals and families.

### Interventions

The findings show that economic changes may have major impacts on homicide rates in children and youths. In societies with high economic inequality, redistributions of wealth without overall increases in per capita GDP may produce smaller reductions in homicide than redistributions combined with overall socioeconomic developments. The findings also suggest that interventions that target economic factors may have the greatest impact on homicide rates in young adults and adolescent males. The impact of such interventions on female homicides may be less, and interventions that target non-economic factors will be needed to have an impact equivalent to that in males.

### Study limitations

Economic development and reducing economic inequality are potential targets to prevent violence. It is important to reflect upon the limitations of this and other studies that explore the relations of these targets with homicide rates.

### Input data

The paucity of low- to middle-income countries and the absence of data from countries in the WHO’s African and Eastern Mediterranean regions (in which projected homicide rates are highest) (4) severely restrict the generalizability of results. With respect to homicide rates, the completeness of death registration varied across the countries, as did the adequacy of ICD coding. Since under-registration and the proportion of undetermined cases tend to be greater in developing countries where homicide rates are higher, however, these limitations are unlikely to have significantly influenced the results. Although the age ranges applied allowed testing of the hypotheses about developmental stages and associations with economic factors, the youngest age range should ideally have included a subcategory for homicide rates per 1 000 live births in infants aged 0–11 months.

### Limitations related to cross-sectional design

Factors other than the economic development and inequality variables that we investigated may have produced the observed associations. For instance, firearms may be more prevalent in societies with higher homicide rates, and greater poverty and inequality could be consequences rather than causes of a high prevalence of firearms.

The study design could be susceptible to aggregation bias; this means that associations observed for pooled countries do not necessarily apply to individual societies. Similarly, an individual society is likely to have substantial differences between urban and rural areas and between different ethnic groups in the extent of homicide, the inequalities investigated and their inter-relations (e.g. 34–37). Unfortunately, uniform data on intracountry differences were unavailable.

### Future work

More cross-sectional studies that use age- and sex-specific data are needed to validate the relations described here. The relation

between the economic factors studied and homicide rates was strengthened, especially for females, when we removed countries regarded as potential outliers from the analyses. These countries did not conform to the general relation, and studies of them could be a particularly rich source of information about the underlying mechanisms of relations.

Hierarchical analyses of the relations between societal wealth, family social class and individual characteristics, such as

sex and age, are needed to explore the contributions of such factors to the causal web of homicide (38). Finally, qualitative work that explores the anthropology and sociology of fatal interpersonal violence in settings with low- and high economic inequalities is needed to reveal the social realities that sustain these patterns of violence. ■

**Conflicts of interest:** none declared.

## Résumé

### Relations par âge et par sexe entre le développement économique, les inégalités économiques et les taux d'homicide chez les 0-24 ans : analyse transversale

**Objectif** Rechercher si les relations entre le développement économique, les inégalités économiques et les taux d'homicide chez les enfants, adolescents et jeunes adultes sont spécifiques de l'âge et du sexe, et si la prospérité d'un pays modifie l'impact des inégalités économiques sur les taux d'homicide.

**Méthodes** La variable à l'étude était le taux d'homicide autour de 1994 chez les 0-24 ans dans 61 pays. Les variables prédictives étaient le produit intérieur brut (PIB) par habitant, le coefficient de GINI, la variation en pourcentage du produit national brut (PNB) par habitant et l'activité économique des femmes en pourcentage de l'activité économique des hommes. Les relations ont été étudiées par analyse de régression ordinaire selon la méthode des moindres carrés.

**Résultats** Toutes les variables prédictives expliquaient la variance significative des taux d'homicide chez les 15-24 ans. Les associations étaient plus fortes pour le sexe masculin que pour le sexe féminin et étaient faibles chez les enfants de 0-9 ans. Les modèles qui incluaient l'inégalité économique des femmes et la

variation du PNB en pourcentage montraient une augmentation de l'effet chez les enfants de 0-9 ans et une augmentation de la part de la variance expliquée chez les femmes de 20-24 ans. Chez les enfants de 0-4 ans, le groupement des pays par revenu augmentait la part de la variance expliquée dans les deux sexes. Chez les 15-24 ans de sexe masculin, l'association avec les inégalités économiques était forte dans les pays à faible revenu et faible dans ceux à haut revenu.

**Conclusion** Les relations entre les facteurs économiques et les taux d'homicide chez les enfants, les adolescents et les jeunes adultes variaient selon l'âge et le sexe. Des interventions axées sur les facteurs économiques auraient l'impact le plus marqué sur les taux d'homicide chez les jeunes adultes et la tranche d'âge supérieure des adolescents de sexe masculin. Dans les sociétés où les inégalités économiques sont importantes, la redistribution des richesses sans augmentation du PIB par habitant ferait moins baisser les taux d'homicide qu'une redistribution associée à un développement économique global.

## Resumen

### Análisis transversal de la relación entre desarrollo económico, desigualdad económica y tasas de homicidio por sexo y edad en la población de 0-24 años

**Objetivo** Determinar si las relaciones entre el desarrollo económico, la desigualdad económica y las tasas de homicidio de niños y jóvenes dependen del sexo y la edad, y si la riqueza de un país influye en la repercusión de las desigualdades económicas en las tasas de homicidio.

**Métodos** Las variables principales fueron las tasas de homicidio en torno a 1994 entre los participantes de 0-24 años de 61 países. Como variables predictivas se emplearon el producto interno bruto (PIB) per cápita, el coeficiente de GINI, la variación porcentual del producto nacional bruto (PNB) per cápita y la actividad económica femenina como porcentaje de la actividad económica masculina. Las relaciones fueron analizadas mediante la regresión de mínimos cuadrados ordinaria.

**Resultados** Todas las variables predictivas explicaron varianzas significativas en las tasas de homicidio entre las personas de 15-24 años. Las asociaciones fueron más importantes en los hombres que en las mujeres, y débiles en los niños de 0-9 años. Los modelos que

incluían la desigualdad económica femenina y la variación porcentual del PNB aumentaron el efecto en los niños de 0-9 años y la varianza explicada en las mujeres de 20-24 años. Por lo que se refiere a los niños de 0-4 años, los conglomerados de países por ingresos aumentaron la varianza explicada en ambos sexos. En el caso de los hombres de 15-24 años, la asociación con la desigualdad económica fue importante en los países con ingresos bajos, y débil en aquellos con ingresos altos.

**Conclusión** La relación entre los factores económicos y las tasas de homicidio de niños y jóvenes dependía de la edad y el sexo. Las intervenciones que apunten a los factores económicos tendrán el máximo impacto en las tasas de homicidio de los adolescentes más mayores y los adultos jóvenes. En las sociedades con importantes desigualdades económicas, una redistribución de la riqueza no acompañada de un aumento del PIB por habitante reduciría las tasas de homicidio menos que una redistribución asociada a un desarrollo económico general.

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## Annex

Table 5 shows the stages of the analyses with homicide rates for males and females aged 0–24 used as an example. It shows the variance in homicide rate (adjusted  $R^2$ ) explained by the variables included in each model and the associated parameter estimates. The latter indicate the increase or decrease in homicide rate (per 100 000 population) for every step of change in the explanatory variables. For model 3, the formula is  $y = x_0 + \ln x_1 + x_2 + x_3 + x_4 + x_4^2$ .

The results show that per capita GDP explained over a third of the variance in rates (adjusted  $R^2$  0.35) and that per capita GDP together with the GINI coefficient (model 1) explained around 50% of the variance. When change in GNP (model 2) and female economic activity rate (model 3) were introduced, the explained variance increased by 12 and 5 percentage points respectively. Overall, model 3 explained

slightly less than 70% of the variance in homicide rates among males and females aged 0–24.

Data on change in GNP and on GINI coefficients were not available for some countries, so the number of countries in the analyses decreased from 61 to 41 during the modelling procedure. We ran each step of the analysis without these countries to test whether the increases in explained variance achieved by adding change in GNP (model 2; 41 countries) and rate of female economic activity (model 3; 41 countries) were artefacts caused by the exclusion of the 20 countries without information. The inclusion of only the 41 countries for which data on all variables were available produced only a 1 percentage points increase in explained variance compared with regressions using all 61 countries. We concluded that the findings were not appreciably influenced by the missing data.

Table 5. Amount of explained variance in the logarithm of homicide rates by economic predictors in the OLS regression model for males and females aged 0–24

Predictor	Parameter estimates (P)			
	GDP (ln)	Model		
		1 <sup>a</sup>	2 <sup>b</sup>	3 <sup>c</sup>
Per capita GDP (ln)	-0.73 (.0001)	-0.61 (0.0001)	-0.29 (0.1063)	-0.19 (0.2986)
GINI coefficient		0.05 (0.0001)	0.06 (0.0001)	0.09 (0.0001)
Percentage change in gross national product (GNP)			-0.16 (0.0009)	-0.17 (0.0005)
Female economic activity				0.07 (0.2960)
(Female economic activity) <sup>2</sup>				0.00 (0.4686)
Intercept	7.30 (0.0001)	4.8 (0.24)	1.3 (0.53)	-3.9 (0.578)
$R^2$	0.36	0.54	0.67	0.73
Adjusted $R^2$ (explained variance)	0.35	0.52	0.64	0.69
Increase in adjusted $R^2$	NA	0.17	0.12	0.05
No of observations	61	54	41	41

<sup>a</sup> GDP (ln) and GINI coefficient.

<sup>b</sup> GDP (ln), GINI and change in gross domestic product (GDP).

<sup>c</sup> GDP (ln), GINI, change in GDP, female economic activity and (female economic activity)<sup>2</sup>.

NA = not applicable.