from hospital specialists. These schemes involve the sale of public assets and commitment of public funds for many years to come, so the information should be publicly available. It is essential that we know what flexibility there is to increase the numbers of beds and levels of clinical services to cope with peaks in emergency admissions.

We expect our clinicians to evaluate new drugs and treatments before they are made widely available to patients. If our politicians aim "to promote efficiency and to improve services" they should evaluate radical changes in the configuration of health services before these changes are implemented throughout the NHS.

1   HM Treasury. *An introduction to the private finance initiative.* London: Treasury, 1997.
2   Department of the Environment. Private Finance Unit. *An introduction to the private finance initiative.* London: Department of the Environment, 1997.
3   NHS Executive. *Bed availability for England, financial year 1995-6.* London: Department of Health, 1996.
4   Stewart A, Butler E. *Seize the initiative.* London: Adam Smith Institute, 1996.
5   NHS Executive. *The PFI guidelines.* Leeds: NHSE, 1995 (HSG (95)15).
6   HM Treasury. *Private opportunity, public benefit.* London: Treasury, 1995.
7   Pollock AM. The NHS goes private. *Lancet* 1995;346:683-4.
8   NHS Executive. *PFI capital investment manuals: business case guide.* Leeds: NHSE, 1995.
9   Unison. *Unison negotiators' guide to the PFI in the NHS.* London: Unison, 1996.
10 NHS Executive. *Code of practice on openness in the NHS.* London: Department of Health, 1997.
11 *Financial report and budget statement, 1997-8.* London: Stationery Office, 1996 (HC 90).
12 Department of Health and Social Security. NHS hospital activity statistics 1974-84. *Statistical Bulletin 5/85.*
13 Department of Health. NHS hospital activity statistics 1982-1992-3. *Statistical Bulletin 10/93.*
14 Department of Health. NHS hospital activity statistics 1984-1994-5. *Statistical Bulletin 95/20.*
15 Department of Health. NHS hospital activity statistics: England. *Statistical Bulletin 1996/23.*
16 Information and Statistics Division. *The NHS in Scotland. Hospitals: bed use summary inpatients by specialty.* Edinburgh: ISD, 1996.
17 Clarke A, McKee M. The consultant episode: an unhelpful measure. *BMJ* 1992;305:1307-8.
18 Information and Statistics Division. *Scottish Health Statistics, 1996.* Edinburgh: ISD, 1996.
19 Radical Statistics Health Group. NHS reforms: the first six months: proof of progress or a statistical smokescreen? *BMJ* 1992;304:705-9.

Life expectancy, economic inequality, homicide, and reproductive timing in Chicago neighbourhoods

Margo Wilson, Martin Daly

Summary

In comparisons among Chicago neighbourhoods, homicide rates in 1988-93 varied more than 100-fold, while male life expectancy at birth ranged from 54 to 77 years, even with effects of homicide mortality removed. This "cause deleted" life expectancy was highly correlated with homicide rates; a measure of economic inequality added significant additional prediction, whereas median household income did not. Deaths from internal causes (diseases) show similar age patterns, despite different absolute levels, in the best and worst neighbourhoods, whereas deaths from external causes (homicide, accident, suicide) do not. As life expectancy declines across neighbourhoods, women reproduce earlier; by age 30, however, neighbourhood no longer affects age specific fertility. These results support the hypothesis that life expectancy itself may be a psychologically salient determinant of risk taking and the timing of life transitions.

Introduction

Psychologists, economists, and criminologists have found that young adults, poor people, and criminal offenders all tend to discount the future relatively steeply.[1-6] Such tendencies have been called "impulsivity" and "short time horizons" or, more pejoratively, impatience, myopia, lack of self control, and incapacity to delay gratification. Behind the use of such terms lies a presumption that steep discounting is dysfunctional and that the appropriate weighting of present rewards against future investments is independent of life stage and socioeconomic circumstance.

There is an alternative view: adjustment of discount rates in relation to age and other variables is just what we should expect of an evolved psyche functioning normally.[5-11] Steep discounting may be a "rational" response to information that indicates an uncertain or low probability of surviving to reap delayed benefits, for example, and "reckless" risk taking can be optimal when the expected profits from safer courses of action are negligible.[7 8 12 13]

Hypothesis 1

Criminal violence can be considered an outcome of steep future discounting[6] and escalation of risk in social competition.[10] This is especially true of homicide in urban parts of the United States, where a large majority of cases involve competition for status or resources among unrelated men[7 9] and even marital homicides result from sexual proprietariness in the shadow of male-male competition.[14 15] This line of reasoning suggests that criminal violence will vary in relation to local indicators of life expectancy, hence our first hypothesis: homicide rates will vary as a function of local life expectancy.

Hypothesis 2

Sensitivity to inequality is an expected feature of a psyche that adjusts risk acceptance as we envision, because those at the bottom may be especially motivated to escalate their tactics of social competition when it is clear that some "winners" are doing very well and when the expected payoffs from low risk tactics are

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Table 1 Effects of life expectancy ("cause deleted" with respect to death from homicide), income, and income inequality on homicide rates of neighbourhoods in Chicago 1988-93: bivariate correlations

	Homicide rate	Life expectancy for males	Life expectancy for females	Median household income*	Robin Hood index
Homicide rate	—				
Life expectancy for males	−0.88	—			
Life expectancy for females	−0.83	0.92	—		
Median household income	−0.67	0.73	0.59	—	
Robin Hood index	0.75	−0.75	−0.66	−0.86	—

*Effects of household size partialled out.

Table 2 Effects of life expectancy ("cause deleted" with respect to death from homicide), income, and income inequality on homicide rates of neighbourhoods in Chicago 1988-93: results of stepwise multiple regression predicting homicide rate of neighbourhoods from the other four variables in table 1

	β	t	P value
Variables in final equation			
Life expectancy of males	−0.74	−9.25	<0.0001
Robin Hood index	0.19	2.34	0.02
Variables not in final equation			
Life expectancy of females	−0.19	−1.43	0.16
Median household income	0.12	1.11	0.27

poor.[12] This expectation accords with arguments that mortality is exacerbated by inequality itself, over and above the compromising effects of simply being poor on nutrition, access to medical care, safety, and other health promoting opportunities.[16 17] Recent papers in the *BMJ* have presented evidence that economic inequality predicts mortality in general, and moreover that it is most strongly related to "external" mortality of the sort affected by behavioural risk taking, especially homicide.[18 19] Accordingly, our second hypothesis is that economic inequality will account for additional variance in homicidal violence besides that accounted for by local life expectancy.

Previous demonstrations of the effects of inequality on homicide have focused primarily on comparisons between nations, American states, or cities.[18-21] The arguments presented above suggest that the relevant processes of social comparison might operate more locally, with the lives and deaths of people known personally being especially salient to one's mental model of life prospects. We have therefore compared neighbourhoods within a large city. This may also be a good level at which to detect the relations of interest because variables such as latitude, weather, urbanness, laws, history, and prevailing political practices complicate comparisons among larger jurisdictions.

Hypothesis 3

Finally, if low life expectancy is indeed psychologically salient in the ways we envision, it will inspire short time horizons in other domains of behavioural decision making as well. Life expectancy cues might thus affect inclinations to invest in the future through education, preventive health measures, and savings, as well as decisions about the timing of major transitions and life events. Geronimus's studies of young mothers support these ideas: although early reproduction among urban poor people is commonly viewed as an instance of social pathology and failure to exercise choice, she has shown that teenage pregnancy is often an active decision, motivated in large part by expectations about

a life course more compressed in time than that of more affluent people.[22 23] Her interviewees in urban ghettoes in the United States expressly wished to become mothers and grandmothers while still young and competent because they anticipated problems of early "weathering" and poor health. Thus, our third hypothesis is that reproduction will occur earlier in the lifespan as one moves from neighbourhoods with high life expectancy to those with low life expectancy.

Data sources

There are 77 "community areas" with relatively stable boundaries in the American city of Chicago. We used demographic data for 1988-93 for these 77 neighbourhoods (vital statistics obtained from the Illinois Department of Public Health) and population data from the 1990 census. Following Schoen's method,[24] we used these data to compute male and female life expectancies at birth for each neighbourhood, "cause deleted" in that effects of homicide mortality were removed. We also computed sex and age specific mortality for different causes of death and age specific birth rates. We used counts of the number of households in each of 25 income intervals, derived from 1990 United States Census population and housing summary tape file 3A, to compute the Robin Hood index of income inequality (the maximum deviation of the Lorenz curve of cumulative share of total income from the straight line that would represent zero income variance[19]) for each neighbourhood.

Life expectancy and homicide

Neighbourhood specific, cause deleted male life expectancy at birth (range 54.3 to 77.4 years) and homicide rates (range 1.3 to 156 per 100 000 per year) are highly correlated, confirming our first hypothesis (fig 1; $r = -0.88$, $P < 0.0001$).

Table 1 shows the bivariate correlations among homicide rates, cause deleted life expectancies, median
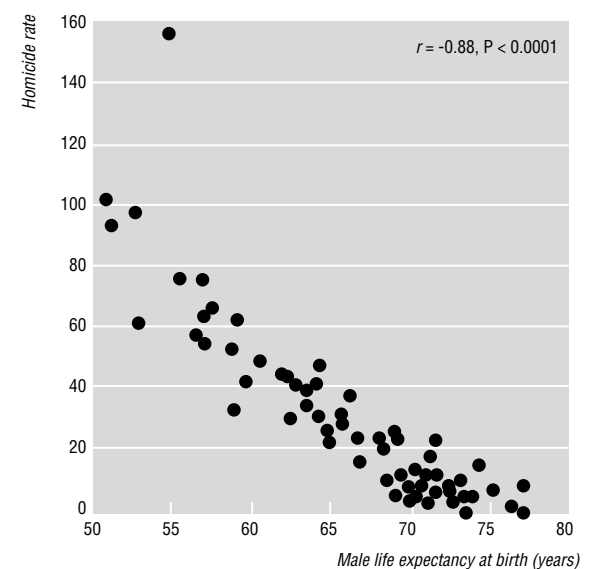
Fig 1 Neighbourhood specific homicide rates (per 100 000 population per year) in relation to male life expectancy at birth (with effects of homicide mortality removed) for 77 community areas of Chicago, 1988-93
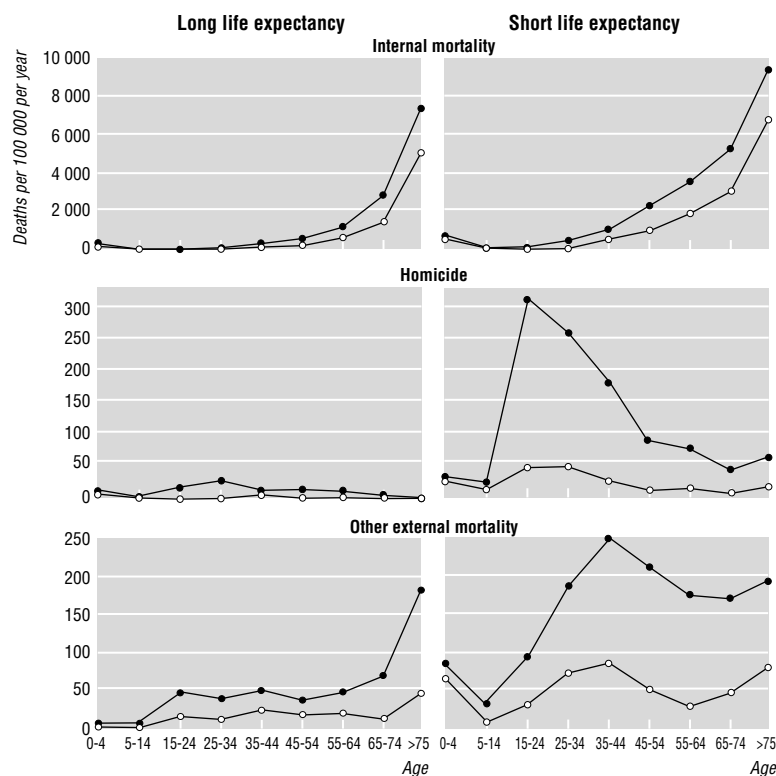
household income (adjusted to remove effects of mean household size, which was correlated with median household income across the 77 neighbourhoods at $r = -0.32$), and a measure of income inequality. All pairs of measures were highly correlated (all P values < 0.0001), but male life expectancy was more strongly related to both economic measures and to the homicide rate than was female life expectancy, and male life expectancy predicted the homicide rate better than either economic measure. Stepwise multiple regression indicated that economic inequality adds significantly to the prediction of homicide rate that is afforded by life expectancy, supporting our second hypothesis. The adjusted median household income is apparently of less relevance than inequality, a result that is consistent with previous findings from comparisons among larger politico-geographic units,[18-21] but since the two economic measures are so highly correlated, this conclusion must be tentative.

Mortality patterns in best and worst neighbourhoods

Figure 2 shows age specific and sex specific death rates, distinguishing death by homicide and other "external" causes (accidents and suicides) from death by "internal" causes (all other causes—that is, by disease, broadly construed). The figure includes data only for the 10 neighbourhoods with the shortest life expectancies (panels on right) and the 10 with the longest (panels on left). Neighbourhoods with low life expectancy have higher levels of all sorts of mortality in virtually all age-sex categories; however, although the pattern of risk of death from internal causes across the lifespan is similar in the best and worst neighbourhoods, age related patterns of external mortality are quite different. These patterns support the idea that differential rates of external mortality are largely a result of differentials in risk acceptance and future discounting, especially in young adults. (Although perpetrating a homicide, rather than becoming a victim, might be thought to reflect risk acceptance and future discounting, the age-sex patterns for perpetrators and victims are similar,[9] largely because homicides in Chicago arise primarily from competitive interactions between male victims and killers who are drawn from the same demographic groups.)

Fig 2 Age specific death rates per 100 000 population per year, according to sex (male ●; female ○) and cause of death for the 10 neighbourhoods with longest life expectancy (left panels) and the 10 with the shortest life expectancy (right panels), Chicago, 1988-93

Life expectancy and age specific birth rates

Table 2 shows age specific birth rates for the 10 neighbourhoods with the highest life expectancies, the 10 with the lowest, and the 10 nearest the median. Teenage birth rates are dramatically different, but the differentials decline rapidly and have vanished by age 30. The median age of women giving birth (the "generation time") was 22.6 years in the neighbourhoods with low life expectancy, compared with 25.4 years in the intermediate neighbourhoods and 27.3 years in the neighbourhoods with long life expectancy. These differences are consistent with our third hypothesis and support Geronimus's suggestion[22 23] that the relatively high birth rates in young women in the worst neighbourhoods often reflect a distinct family planning schedule rather than a mere absence of family planning.

Effect of life expectancy

Life expectancy reflects not only affluence but such additional considerations as local pathogen loads, health care, and risk of violent death, and it may thus provide a more encompassing quality of life index than economic measures alone. More than just providing a useful epidemiological index, however, an "expectation" of future lifespan may be psychologically salient in its own right, although it need not be a conscious expectation. The data presented here indicate that people behave as if they have adjusted their rates of future discounting and risk acceptance thresholds in relation to local life expectancy, and that they do so in the non-violent domain of reproductive decision making as well as in the potentially violent domain of social competition.

Table 3 Age specific birth rates (per 1000 women per year) in 10 neighbourhoods with longest life expectancy, 10 with shortest life expectancy, and 10 nearest median life expectancy in Chicago, 1988-93

Age of mother (years)	Birth rate in neighbourhoods		
	Shortest life expectancy	Median life expectancy	Longest life expectancy
10-14	9	2	1
15-19	190	86	45
20-24	224	128	90
25-29	129	103	103
30-34	83	84	89
35-39	39	43	42
40-44	9	10	7

How could such a statistical abstraction as life expectancy be a cause of anything? One possibility is that the human psyche produces what is in effect a semi-statistical apprehension of the distribution of local lifespans, based on the fates of other relevant people.[10] If a young man's grandfathers were both dead before he was born, for example, and some of his primary school classmates had already died, discounting the future could be a normal, adaptive reaction. Moreover, if much of this mortality seems to represent "bad luck" incurred more or less independently of the decedents' choices of action, then accepting more risks in the pursuit of immediate advantage would also make sense.

These inference processes are unlikely to be transparent to introspection, but they may be revealed in expressed attitudes and expectations. Ethnographic studies of urban poor people in American cities contain many articulate statements about the perceived risk of early death, the unpredictability of future resources, and the futility of long term planning.[25-28] One interesting question for psychological research is how the relevant mental models and subjective values develop and are adjusted over the lifespan.[29 30] Another is whether media representations, even fictitious ones, can affect such development in the same way as information about known relatives and neighbours. These questions may best be addressed from an evolutionary psychological perspective, which credits the mind with functional "design" for solving important problems of living in society and making decisions under uncertainty.[10 29 31 32] Such an approach has already shed considerable light on detailed aspects of sex differences and age effects.[5 9]

Feedback effects

The regression analysis in table 1 and our emphasis on life expectancy as a predictive variable must not be taken to imply that economic inequality plays only a secondary role. Considerable evidence indicates that such inequality is itself a major determinant of life expectancy variation,[17] so the more basic (and remediable) causes of violence and other manifestations of steep future discounting are socioeconomic and structural. How our proposal differs from some other accounts is in suggesting that inequality has its effects not only by virtue of non-adaptive or maladaptive stress effects but also by inspiring a "rational" escalation of costly tactics of social competition.[7-10 33] This consideration complicates causal analysis, because it implies that the distribution of age specific mortality is more than an outcome variable, having feedback effects on its own causal factors and hence on itself. We excluded deaths due to homicide from the analyses in table 1 to eliminate spurious autocorrelational effects, but it is likely that local levels of homicidal violence affect expectations of future life, discount rates, and hence further violence.[8]

The number of likely feedback loops among the phenomena of interest is daunting. If many people react to a local socioecological milieu by discounting the future and lowering their thresholds for risk and violence, the behavioural consequences are likely to worsen the very problems that provoke them, as well as contributing to fear, distrust, and perhaps even economic inequality itself. Living where any resources that one accumulates are apt to be expropriated will also exacerbate these tendencies. Wilkinson has proposed that the behavioural and health effects of unequal resource distributions reflect breakdowns in social and community relations, a proposition that we do not dispute. But exactly how the correlated phenomena of poverty, inequality, injustice, and exogenous threats to life and wellbeing affect the perceptions, motives, and actions of individuals remains to be elucidated. The causal links are several and multidirectional, but we cannot let that deter us from trying to disentangle them.

1 Gottfredson MR, Hirschi T. *A general theory of crime.* Stanford, CA: Stanford University Press, 1990.
2 Green L, Fry AF, Myerson J. Discounting of delayed rewards: a life-span comparison. *Psychological Science* 1994;5:33-3.
3 Lawrance EC. Poverty and the rate of time preference: evidence from panel data. *Journal of Political Economy* 1991;99:54-77.
4 Loewenstein G, Elster J, eds. *Choice over time.* New York: Russell Sage, 1992.
5 Rogers AR. Evolution of time preference by natural selection. *American Economic Review* 1994;84:460-81.
6 Wilson JQ, Herrnstein RJ. *Crime and human nature.* New York: Simon and Schuster, 1985.
7 Wilson MI, Daly M. Competitiveness, risk-taking and violence: the young male syndrome. *Ethology and Sociobiology* 1985;6:59-73.
8 Daly M, Wilson MI. *Homicide.* Hawthorne, NY: Aldine de Gruyter, 1988.
9 Daly M, Wilson MI. Killing the competition. *Human Nature* 1990;1:83-109.
10 Daly M, Wilson MI. Crime and conflict: homicide in evolutionary psychological perspective. *Crime and Justice* 1997;22:251-300.
11 Charlton BG. What is the ultimate cause of socio-economic inequalities in health? An explanation in terms of evolutionary psychology. *J R Soc Med* 1996;89:3-8.
12 Rubin PH, Paul CW. An evolutionary model of taste for risk. *Economic Inquiry* 1979;18:585-96.
13 Kacelnik A, Bateson M. Risky theories—the effects of variance on foraging decisions. *American Zoologist* 1996;36:402-34.
14 Wilson MI, Daly M. Who kills whom in spouse killings? On the exceptional sex ratio of spousal homicides in the United States. *Criminology* 1992;30:189-215.
15 Wilson MI, Daly M. The man who mistook his wife for a chattel. In: Barkow J, Cosmides L, Tooby J, eds. *The adapted mind.* New York: Oxford, 1992:289-322.
16 Wilkinson RG. Income distribution and life expectancy. *BMJ* 1992;304:165-8.
17 Wilkinson RG. *Unhealthy societies: the afflictions of inequality.* London: Routledge, 1996.
18 Kaplan GA, Kamuk ER, Lynch JVV, Cohen RD, Balfour JL. Inequality in income and mortality in the United States: analysis of mortality and potential pathways. *BMJ* 1996;312:999-1003,1253.
19 Kennedy BP, Kawachi I, Prothrow-Stich D. Income distribution and mortality: cross sectional ecological study of the Robin Hood index in the United States. *BMJ* 1996;312:1004-7,1194.
20 Krahn H, Hartnagel TF, Gartrell JW. Income inequality and homicide rates: cross-national data and criminological theories. *Criminology* 1986;24:269-95.
21 Hsieh C-C, Pugh MD. Poverty, income inequality and violent crime: a meta-analysis of recent aggregate data studies. *Criminal Justice Review* 1993;18:182-202.
22 Geronimus AT. The weathering hypothesis and the health of African-American women and infants: evidence and speculation. *Ethnicity and Disease* 1992;2:207-21.
23 Geronimus AT. What teen mothers know. *Human Nature* 1996;7:323-52.
24 Schoen R. Calculating life tables by estimating Chiang's α from observed rates. *Demography* 1978;15:625-34.
25 Hagedorn JD. *People and folks.* Chicago: Lake View Press, 1988.
26 Jankowski MS. *Islands in the street.* Berkeley: University of California Press, 1992.
27 Waldman L. *My neighborhood: the words and pictures of inner-city children.* Chicago: Hyde Park Foundation, 1993.
28 Wilson WJ. *The truly disadvantaged: the inner city, the underclass, and public policy.* Chicago: University of Chicago Press, 1987.
29 Hill EM, Ross LT, Low BS. The role of future unpredictability in human risk-taking. *Human Nature* (in press).
30 Nisbett RE, Cohen D. *Culture of honor: the psychology of violence in the South.* Boulder, CO: Westview Press, 1996.
31 Barkow J, Cosmides L, Tooby J, eds. *The adapted mind.* New York: Oxford, 1992.
32 Gigerenzer G, Goldstein DG. Reasoning the fast and frugal way: models of bounded rationality. *Psychol Rev* 1996;103:650-69.
33 Frank RH. *Choosing the right pond.* New York: Oxford, 1985.