1. INTRODUCTION

Each year approximately 1500 mountaineers venture to the Himalayan peaks of Nepal (Salisbury 2004). Their triumphs and tragedies have attracted international attention for nearly a century, but a climber’s odds of summiting or of dying have rarely been quantified (Town 1986; Pollard & Clarke 1988; Huey & Eguskitza 2000; Huey et al. 2001; Huey & Salisbury 2003). In particular, whether those odds differ by age or gender has never been examined and is challenging to predict. Regardless of the level of prior experience (0, 1) based on whether a climber had previously attempted a Nepalese peak, as mountaineering experience elsewhere is unknown. Even though climbers usually climb in teams (Huey & Eguskitza 2000), we treated individual climbers as independent because we are analysing attributes (e.g. age, gender) of individuals.

2. MATERIAL AND METHODS

Mountaineering data were obtained by Elizabeth Hawley, who collected them via intensive interviews and correspondence over four decades (McDonald 2005). Her archives were converted into a database by Salisbury (2004). We analysed data for mountaineers (n = 2211, 1990–2005) making their first attempt on Everest, thereby avoiding non-independence. We included only ‘members’ on climbing permits and thus excluded high-altitude assistants and porters, who have different responsibilities (and for whom age is often unknown). Chinese expeditions were also excluded, as local authorities do not distinguish members and porters. Data are for spring, when most attempts are made (77.9% of climbers between 1990 and 2005), and for climbers (88.2% of spring climbers) using the Southeast Ridge in Nepal versus the Himalayan peaks of Nepal (Salisbury 2004). Their odds of summiting or of dying have rarely been quantified (Town 1986; Pollard & Clarke 1988; Huey & Eguskitza 2000; Huey et al. 2001; Huey & Salisbury 2003). Age and gender were known for most climbers (98% and 100%, respectively). We treated individual climbers as independent because we are analysing attributes (e.g. age, gender) of individuals.

(a) Statistical analyses

Exploratory analyses suggested that rates (e.g. of summiting) were nonlinearly related to age and appeared to show a ‘breakpoint’, an age at which rates shifted abruptly. A non-parametric approach based on generalized additive models (GAMs, Hastie & Tibshirani 1990) confirmed that log odds were nonlinearly related to age and showed a breakpoint. Thus, logistic regression is unsuitable; instead, we used joint-point models, where log odds are piecewise linear at the breakpoint. Specifically, we report quasi-binomial models (generalized linear models, GLMs, with a dispersion parameter) with factors (gender, prior experience and route), a joint-point model for age and year of climb as a covariate. A route factor partitioned attempts via the Southeast Ridge in Nepal versus those from Tibet (n = 878 and 1333, respectively; see Huey & Salisbury 2003). Interactions were non-significant. In analyses of death rates, year of climb had significant nonlinear effects; thus, we used semi-parametric GAMs that were similar to GLMs, but including a non-parametric effect of year. Statistics were computed in R (Ihaka & Gentleman 1996).

3. RESULTS

The gender ratio and age structure on Everest has been shifting since the first ascent in 1953. Men still outnumber women, but women are increasing in proportion (p < 0.001; table 1) and constituted approximately 10% of all climbers between 2000 and 2005. The ‘greying’ of mountaineers on Everest is also apparent (table 1). In the early decades, 18.7% of climbers were equal to or older than 40 years (the age at which summit rate begins to drop; figure 1a) and only 0.3% were equal to or older than 60 years (the age at which death rates increase; figure 1). In recent years (2000–2005), 45.6% were 40 years old and above and 3.6% were 60 years old and above. In particular, 12.5 sexagenarians per year attempted Everest between 2000 and 2005.

For the period of 1990–2005, climbers ranged from 15 to 69 years (grey histogram; figure 1b), though 50% were between 31 and 43. Most (88.8%) were men and few (38.1%) had prior experience on a Nepalese peak, but men were slightly more likely to have prior experience than women (38.9% versus 32.0%, p = 0.041). Prior experience increased by judgement and skill gained from years of experience. Here we study climbers on Mount Everest, the world’s highest peak. We calculated whether the odds of summiting or of dying differ by age and gender, and whether those odds have changed in recent years. Over 450 climbers are attempting Everest annually, and an increasing proportion are women and older climbers; thus, statistical power is sufficient to explore gender- and age-dependent patterns. Moreover, data are reliable and consistent, as they were obtained by a single rigorous interviewer (Salisbury 2004; McDonald 2005).
but varied nonlinearly with year (independent of experience and route (both 1.62 and 1.63%, respectively). Death rate was also

We fit a GAM joint-point regression model (less than

summiting was independent of gender (men 2.3%,

and then increased significantly (p=0.037). A joint-point regression analysis was again suggestive (p=0.10). However, since only 60 climbers were sexagenarians and only three of them died, an increased overall death rate for sexagenarians is tentative.

A comparison of overall death rates underestimates risks facing older climbers, simply because very few older climbers reach extreme altitudes (figure 1a) where risk is greatest. To compare the death rates of climbers who reached equivalent altitudes, we analysed the death rates only of climbers descending from Everest’s summit (N=677; figure 1b). We used a GAM joint-point regression that improved the fit (p=0.001). Descent death rate was essentially constant until the age of approximately 60 years (p=0.89) and then increased significantly (p=0.0004). Descent death rate was independent of gender (men 2.3%, women 4.3%, p=0.20) and experience (p=0.43), but varied nonlinearly with year (p=0.06), again reflecting storm deaths in 1996. Not surprisingly, the overall success rate (above) decreased steeply for climbers older than approximately 40 years (p<0.001; figure 1b) but did not differ between men and women (30.3 and 27.1%, respectively, p=0.36).

4. DISCUSSION

Over a half century has elapsed since the first ascent of Everest, and the number of climbers attempting Everest continues to grow. The number and proportion of women and older climbers are increasing (table 1), hence we examined whether a climber’s odds of summiting or of dying varied by gender or
We found that women and men have similar odds of summing, death overall and death during descent. In fact, none of these odds even approaches statistical significance, so this pattern is robust. Similarity of these odds may reflect similar physiological performance of men and women in hypoxia and cold (Wagner et al. 1979; Wagner & Horvath 1985; Ward et al. 2000; Roach & Kayser 2001), as well as similar resistance to acute mountain sickness (Schneider et al. 2002).

Older climbers are also increasing in number and proportion on Everest (table 1), probably reflecting general demographic and health trends (Burtscher 2004). However, climbers older than approximately 40 years clearly face an uphill battle to summit Everest (figure 1a), and those in their 60s achieve the summit far less frequently (13.3%) than do those in their 30s (35.7%). Older climbers may be less likely to summit because they are physically less capable (Moore 1975; Burtscher 2004; Tsianos et al. 2006) or they climb in a more conservative manner.

Climbers older than approximately 60 years also have elevated death rates (figure 1), which challenges a proposal (Kinoshita et al. 2000) that sexagenarians can safely climb 8000 m peaks. In fact, sexagenarians had an overall death rate approximately three times higher than that of younger climbers (5.0% versus 1.5%, risk ratio = 3.3, 95% CI 1.1–9.4), even though they rarely summit. Moreover, sexagenarians who summited had a death rate strikingly higher (25% versus 2.2%, p = 0.015; risk ratio = 11.1, 95% CI 3.0–31.7) than that of younger summiters (figure 1).

Climbers with prior experience on a Nepalese peak had elevated rates of summiting (38.7% versus 25.7%) though not a lower death rate (1.8% versus 1.5%). Increased odds of summiting might reflect direct benefits of prior experience (Kinoshita et al. 2000) or self-selection; perhaps only climbers who performed well on a lower peak later returned to attempt Everest.

When evaluating whether to attempt Everest, mountaineers should have access to quantitative data on their odds of summiting and of death. We find that these odds are independent of gender, but sensitive to age. On Everest, youth and vigour trump age and experience.

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