Supplemental Oxygen and Mountaineering Deaths

O_2: the extra breath of life on Everest and K2?

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The higher one climbs, the harder one works to climb. The increasing scarcity of oxygen with altitude is the reason, of course. One way to compensate is to breathe supplemental oxygen, an idea first suggested in 1878 by the French physiologist Paul Bert. Supplemental oxygen was first used in the Himalaya just after the turn of the century and extensively by British Everest expeditions in the 1920s. It is currently used by most climbers on Everest.

Right from the beginning of its use, however, supplemental oxygen has provoked debates, and even today it sparks passionate exchanges (for example, between A. Boukreev and J. Krakauer). Several issues have received the brunt of discussion.

Does supplemental oxygen enhance overall performance? Given the widespread use of supplemental oxygen on Everest today, this may seem like an odd question. However, in the early 1920s and even into the late 1940s, this question was serious and unresolved. At issue was whether the physiological "benefit" of supplemental oxygen would outweigh the "cost" of having to carry heavy and cumbersome backpacks (some weighing more than 30 pounds) and of having to deal with high-resistance masks and unreliable regulators. Observations by G.I. Finch on Everest in 1922 showed, however, that climbers using supplemental oxygen not only climbed considerably faster than those not using supplemental oxygen but also slept better. Many later studies, as well as the experiences of mountaineers themselves, reinforced the conclusion that supplemental oxygen does enhance overall climbing speed and performance.

Do climbers need supplemental O_2 to reach the summit of Everest? For decades, this issue was hotly debated, both by mountaineers and by medical physiologists. In 1978, Reinhold Messner and Peter Habeler dramatically silenced the debate by summiting Everest without supplemental oxygen, thus proving that at least some individuals had the physical and mental capacity to reach the summit and return safely on ambient air alone.

Is the use of supplemental oxygen aesthetic or ethical? This was—and still is—a question that each climber must answer personally. Although he himself used supplemental oxygen on Everest, G.L. Mallory disliked its use in part on aesthetic grounds "...When I think of mountaineering with four cylinders of oxygen on one's back and a mask over one's face—well, it loses its charm."

H.W. Tilman argued in 1948 that climbing with supplemental oxygen use was not climbing by "fair means," a theme that later became Messner and Habeler's famous motto. Messner's opposition to supplemental oxygen is cogent: "By reaching for an oxygen cylinder, a climber degrades Everest to the level of a 6000-meter peak...."

Should supplemental oxygen use be required for guides? This new debate has been prompted, of course, by the recent rise of guided expeditions to Everest and especially by the

tragedies on Everest in 1996.

Does supplemental oxygen enhance safety? The positive effects of supplemental oxygen on a climber's speed and performance suggest that supplemental oxygen use might well enhance climber safety, as G. Pugh argued in 1957. Yet, despite all the debates over supplemental oxygen, this issue has not previously been studied directly. We begin such a study here.

To explore a potential link between supplemental oxygen use and safety, we decided to investigate whether death rates on K2 and Everest differed depending on whether or not a climber had used supplemental oxygen. Any impact of supplemental oxygen on safety is likely to be most conspicuous in an analysis of death rates of mountaineers descending from these summits: such mountaineers are often near their physical limits and thus should be especially vulnerable to accident, medical emergency or mental error during their dangerous descent. So we decided to begin by focusing on death rates during descent from the summit of these peaks.

The basic data were obtained by interviews with climbers (primarily by Elizabeth Hawley for Everest and by X. Eguskitza for K2). Most of these data are readily available in standard books but were corrected and updated through December, 1999. For Everest, we analyzed data from 1978 (first ascent without supplemental oxygen) through 1999. For K2, we analyzed data from 1978 (first ascent without supplemental oxygen) through 1997 only, as no climber reached the summit of K2 in 1998 or 1999. For all climbers known for certain to have reached the summit, we determined whether they used supplemental oxygen at any time on the mountain (during either ascent or descent, or while resting or sleeping) and whether they died during descent. We then used formal statistical analyses to search for an association between use of supplemental oxygen and death rates during descent (for statistical details, see Huey and Eguskitza, *Journal of the American Medical Association, 2000,* **284**:181).

We first computed the overall death rates of all climbers reaching the summit. The danger of reaching the summits of these peaks is clearly evident. On Everest, one in 29 climbers (3.4 percent) who reached the summit during the survey period died during descent. On K2, one in seven (13.4 percent) died (Table 1). Sadly, K2's lethal reputation is accurate.

Next, we compared death rates during descent of climbers based on use of supplemental oxygen. Death rates for climbers not using supplemental oxygen were significantly higher than for those who did (Table 1). On Everest, climbers not using supplemental oxygen had death rates more than double those using supplemental oxygen (8.3 percent vs. 3.0 percent). On K2, the difference is overwhelming (18.8 percent vs. 0 percent). Essentially, one in five climbers who did not use supplemental oxygen died during descent from the summit of K2.

Because Himalayan mountaineers usually climb in groups and sometimes die in groups, the above statistical analyses of death rates of individual climbers are potentially suspect. In particular, the high death rate on K2 is undoubtedly inflated by the simultaneous deaths of many climbers trapped by huge storms (1986, 1995). As a precaution, we did an additional analysis of "summit teams" rather than of individuals, where a summit team is defined as a group of climbers who reached the summit on a given day via a given route. In effect, this second analysis asks whether teams using supplemental oxygen were more or less likely to suffer the death of at least one team member. Thus this analysis counteracts the bias induced in individual death rates by multiple deaths in storms. For each summit team, we determined whether climbers had used supplemental oxygen and whether anyone died during descent. A few teams had mixed use of supplemental oxygen, and we split such teams into two.

Teams not using supplemental oxygen were significantly more likely to suffer a death during descent than were teams using supplemental oxygen. The difference on Everest is small (12.5 percent vs. 7.5 percent), but the difference on K2 is again overwhelming (34.3 percent vs. 0 percent): one in three K2 summit teams not using supplemental oxygen suffered the loss of one or more climbers during descent. Thus, the high individual death rate on K2 (above) is not only an inflated consequence of a few deadly storms that each killed many climbers.

These analyses validate a fact that Himalayan mountaineers already appreciate, namely, that reaching the summit of Everest and especially of K2 is dangerous (Table 1). However, these analyses show for the first time that reaching these summits without supplemental oxygen is suggestively even more dangerous (Table 1). We emphasize that these analyses cannot prove that mountaineers using supplemental oxygen had lower death rates because they used supplemental oxygen. Perhaps such mountaineers have lower death rates instead because they are more cautious in general and take fewer chances. For example, mountaineers using supplemental oxygen might be more likely to have better equipped their high camps, and access to these crucial supplies during storms (rather than supplemental oxygen) could have been the actual reason for their enhanced survival (L. Reichardt, personal communication).

Nevertheless, two reasons suggest that supplemental oxygen does have a direct impact on death rates. First, by enhancing climbing speed and performance, use of supplemental oxygen will almost certainly enhance climber safety as well. Second, because those few climbers able to reach these summits without using supplemental oxygen are likely to be on average relatively fit, skilled and experienced, they should have lower—not higher—death rates than climbers using supplemental oxygen, all else being equal. Consequently, the direct impact of supplemental oxygen on death rates during descent might be even greater than suggested in Table 1, were we able to standardize climbers by skill and experience.

Although our analyses suggest that use of supplemental oxygen directly lowers death rates of individual climbers (or of summit teams) who have reached the summit, they do not address a separate and important question: Does supplemental oxygen lower total deaths on an expedition? Potentially, use of supplemental oxygen could indirectly lead to more total deaths for two reasons. First, because porters are normally used to ferry oxygen canisters to high altitudes, an expedition using supplemental oxygen will necessarily be large and thus expose more people to risk. Second, use of supplemental oxygen undoubtedly enables more climbers to attempt and reach the summit, where risk of death is high. [Note: these two arguments apply principally to Everest, as porters and oxygen are rarely used on K2.] Ultimately, a more comprehensive analysis will thus be necessary to address the issue of total death risk.

Himalayan mountaineers make many decisions that require them to balance adventure against acceptable risk. One key decision is whether to use supplemental oxygen. The decision to climb with supplemental oxygen appears to promote an individual climber's chance of survival, at least during descent from the summit of Everest or K2. However, whether the use of supplemental oxygen itself is the direct cause of that higher survival cannot be determined conclusively. But we hope these patterns will encourage further discussion of factors that influence survival and success on the high peaks.

The authors would like to thank E. Hawley for generously sharing data; C. Bonington, T. Hornbein, C. Houston, L. Reichardt and J. West for constructive comments and discussion; and the J. S. Guggenheim Foundation for support.

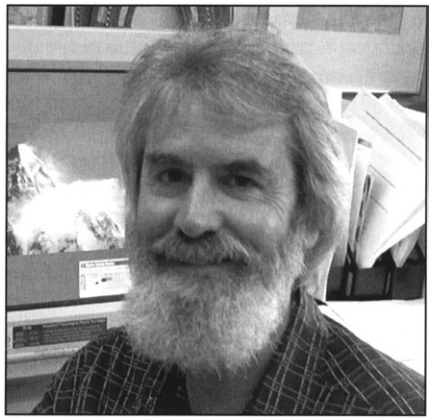
Table 1. Use of supplemental oxygen is associated with lower death rates of mountaineers descending from the summits of Everest (1978-1999) and of K2 (1978-1997).

Everest

Use of Supplemental Oxygen	Number of Ascents	Number of Deaths	Percentage of Deaths
yes	1077	32	3.0
no	96	8	8.3
Total	**1173**	**40**	**3.4**

K2

Use of Supplemental Oxygen	Number of Ascents	Number of Deaths	Percentage of Deaths
yes	47	0	0
no	117	22	18.8
Total	**164**	**22**	**13.4**



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