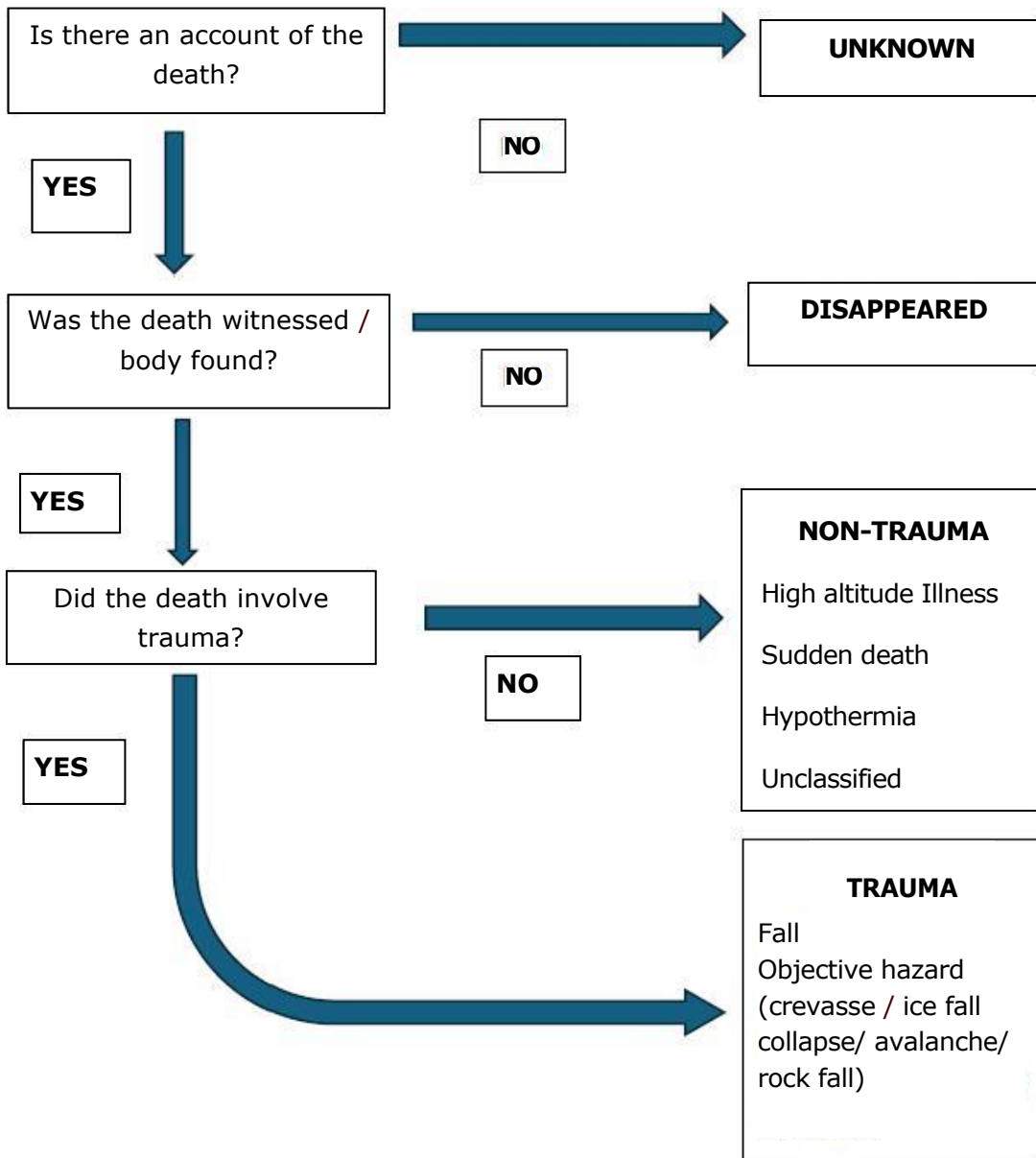


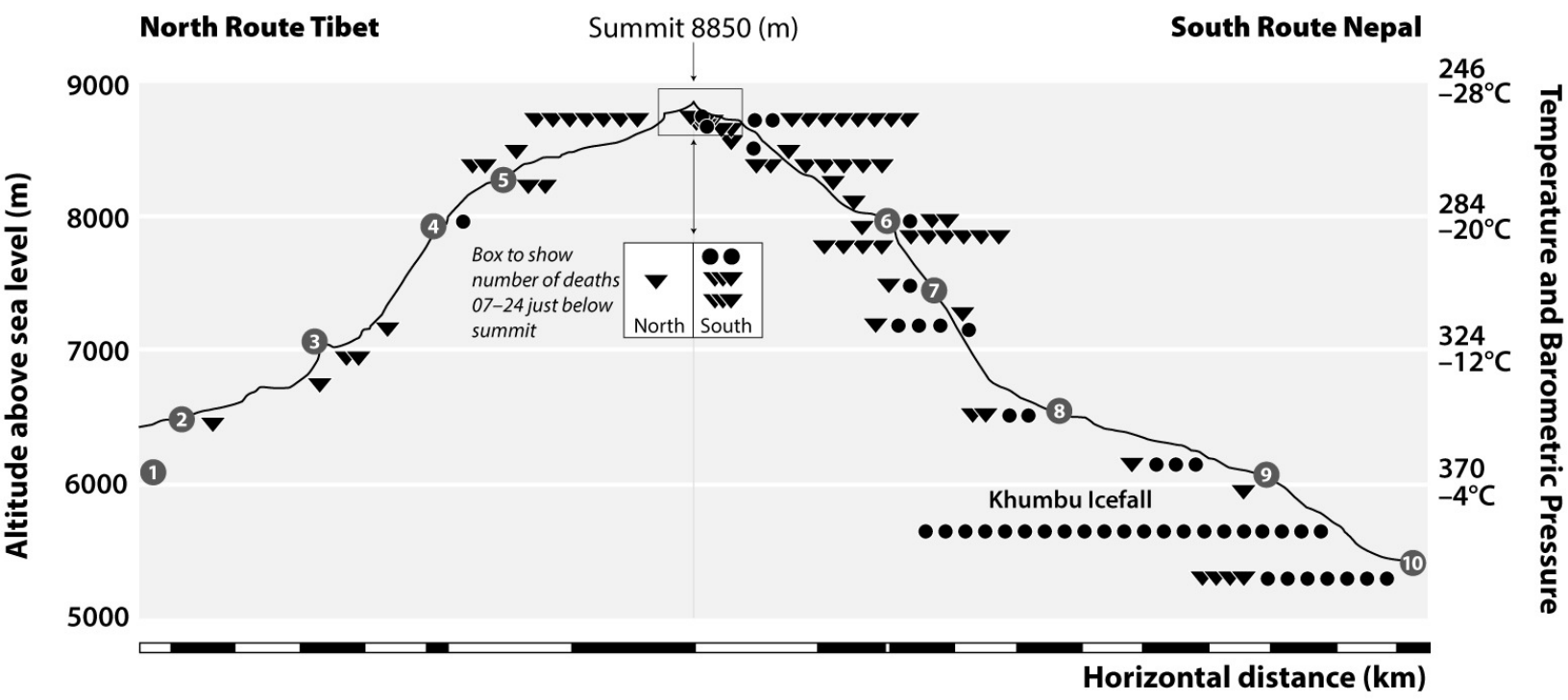
- ▼ Deaths of Climbers (07-24)
- Deaths of Sherpas (07-24)

- Camps North Route**
- ① Yak
 - ② ABC
 - ③ North Col
 - ④ Camp 2
 - ⑤ Camp 3

- Camps South Route**
- ⑥ South Col
 - ⑦ Camp 3
 - ⑧ Camp 2
 - ⑨ Camp 1
 - ⑩ Base Camp



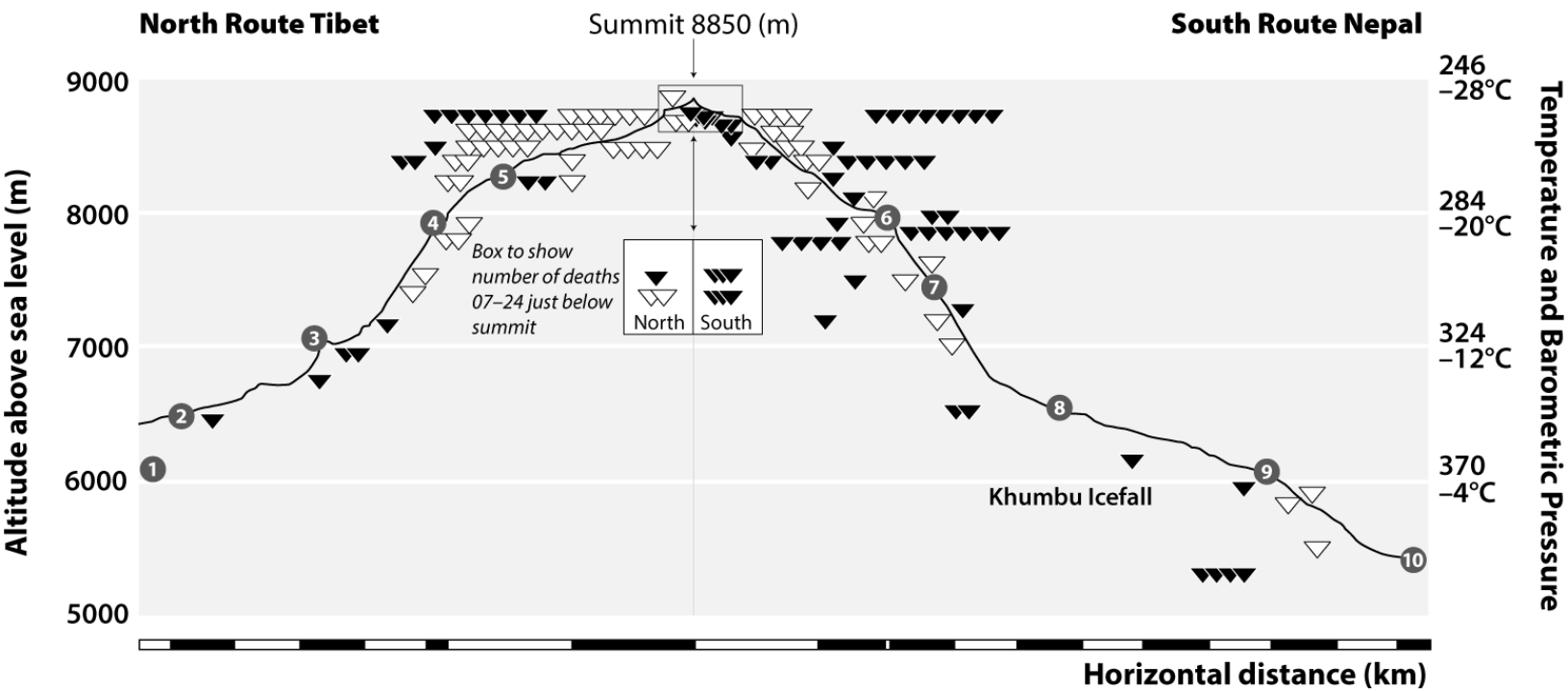




- ▼ Deaths of Climbers (07-24)
- Deaths of Sherpas (07-24)

- Camps North Route**
- ① Yak
 - ② ABC
 - ③ North Col
 - ④ Camp 2
 - ⑤ Camp 3

- Camps South Route**
- ⑥ South Col
 - ⑦ Camp 3
 - ⑧ Camp 2
 - ⑨ Camp 1
 - ⑩ Base Camp

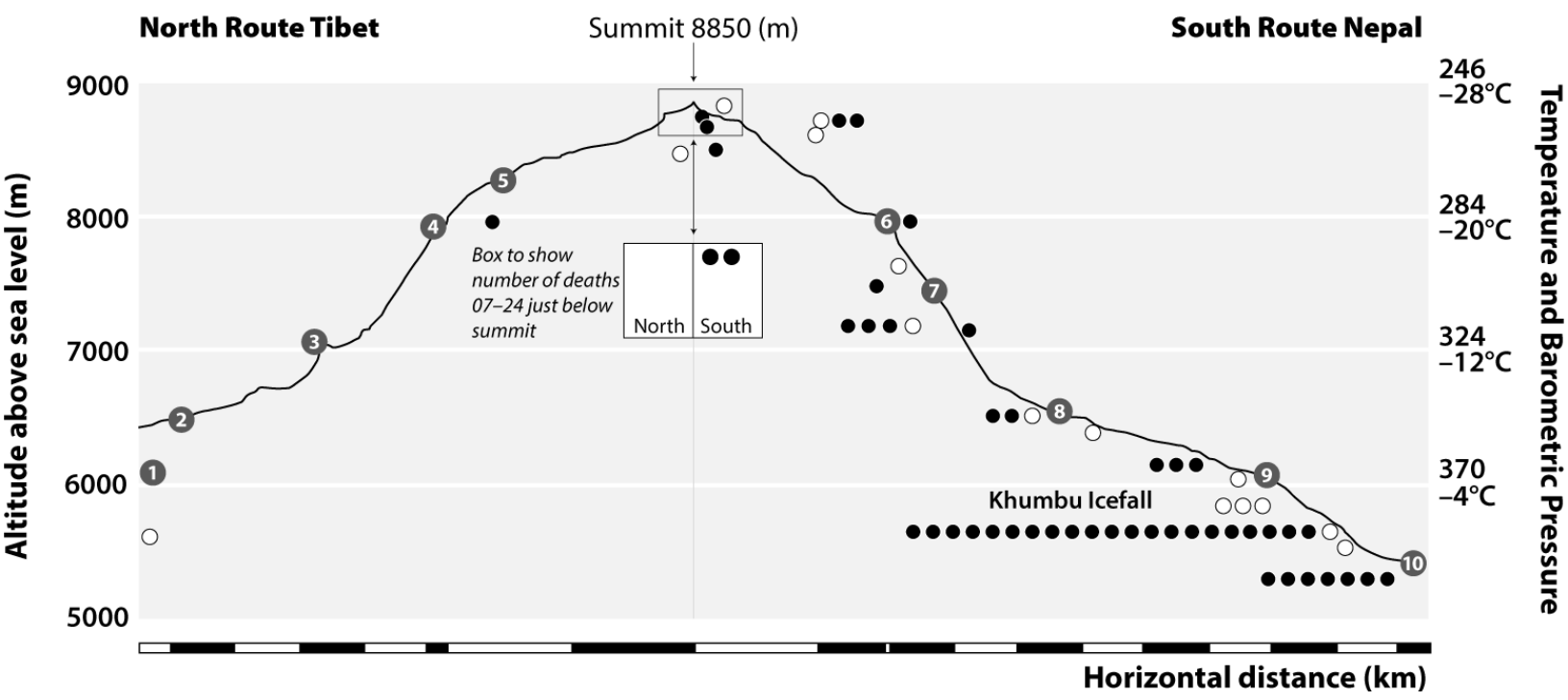


- ▽ Deaths of Climbers (82-06)

- ▼ Deaths of Climbers (07-24)

- Camps North Route**
- ① Yak
 - ② ABC
 - ③ North Col
 - ④ Camp 2
 - ⑤ Camp 3

- Camps South Route**
- ⑥ South Col
 - ⑦ Camp 3
 - ⑧ Camp 2
 - ⑨ Camp 1
 - ⑩ Base Camp

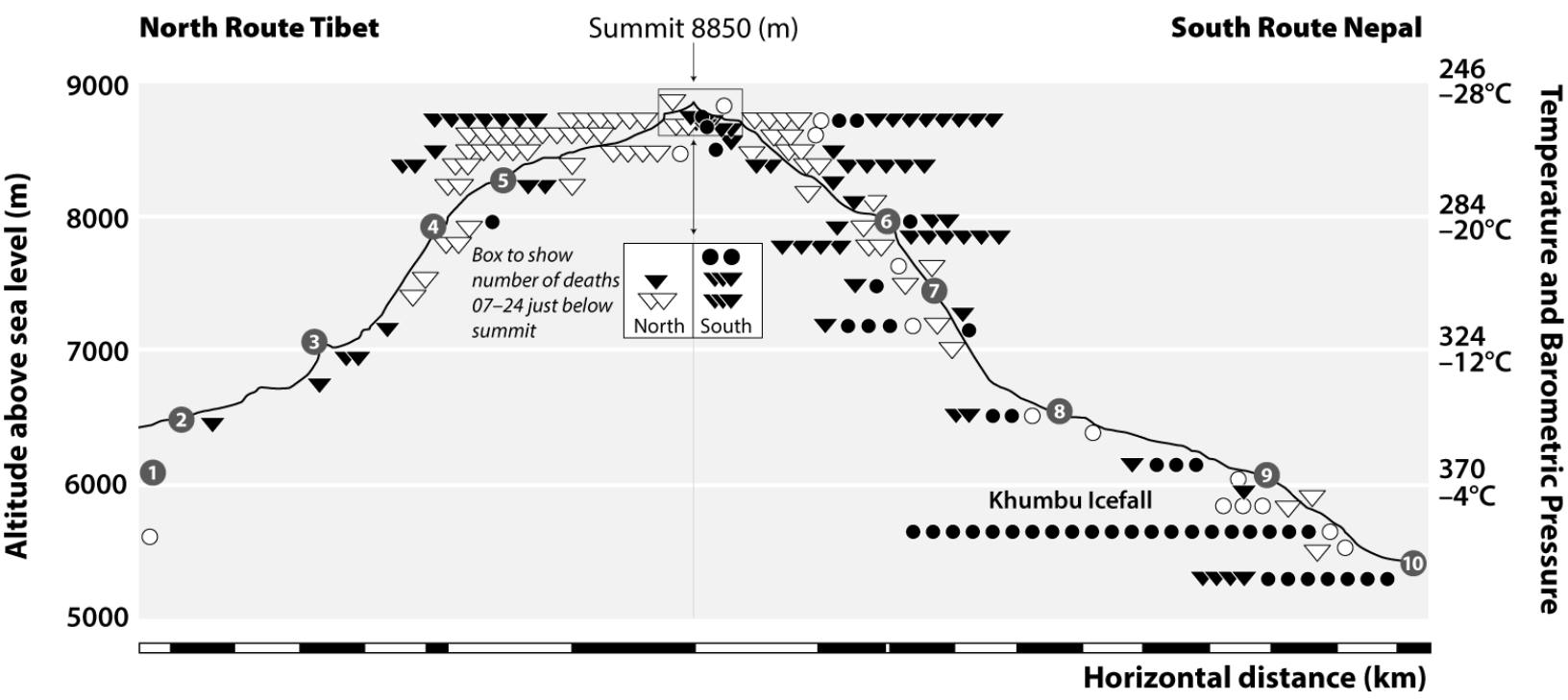


- Deaths of Sherpas (82-06)

- Deaths of Sherpas (07-24)

- Camps North Route**
- ① Yak
 - ② ABC
 - ③ North Col
 - ④ Camp 2
 - ⑤ Camp 3

- Camps South Route**
- ⑥ South Col
 - ⑦ Camp 3
 - ⑧ Camp 2
 - ⑨ Camp 1
 - ⑩ Base Camp



- ▽ Deaths of Climbers (82-06)
- Deaths of Sherpas (82-06)

- ▼ Deaths of Climbers (07-24)
- Deaths of Sherpas (07-24)

- Camps North Route**
- ① Yak
 - ② ABC
 - ③ North Col
 - ④ Camp 2
 - ⑤ Camp 3

- Camps South Route**
- ⑥ South Col
 - ⑦ Camp 3
 - ⑧ Camp 2
 - ⑨ Camp 1
 - ⑩ Base Camp

1 **Title:**
2 **Updates to Mortality on Mount Everest: 1921-2024**

3
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25
26 **Running Title:** Mortality on Everest
27

28 **KEY POINTS**

- 29 • Climbing techniques on Mount Everest have changed in recent years, which may impact
30 patterns of mortality.
- 31 • Overall mortality rates from 1921-2006 versus 2007-20024 decreased from 1.4% to
32 0.7%.
- 33 • Most climbers still die on summit day, but mortality rates during descent from the
34 summit decreased from 3.0% to 0.8%.
- 35 • Above 8000m, there are less death involving falls or climbers separated from their group,
36 but profound exhaustion and impaired consciousness are still frequent symptoms of those
37 who died in this hypoxic environment.
- 38 • Awareness of the persistent patterns of mortality may help mountaineers avoid fatal
39 situations.

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43 **ABSTRACT**

44 **INTRODUCTION:** Mount Everest is climbed by an increasing number of mountaineers.
45 Although climbing techniques have changed in recent years, the impact on patterns of mortality
46 is unclear.

47 **METHODS:** To compare mortality patterns from 1921-2006 with 2007-2024, we performed a
48 retrospective observational study of mountaineers climbing Everest. We extracted data from the
49 Himalayan Database and examined accounts of deaths.

50 **RESULTS:** The overall mortality rate above base camp decreased from 1.4% to 0.7%, $p < 0.001$.
51 From 2007 to 2024, the mean altitude of fatal incidents on the standard routes involving climbers
52 was higher than those involving involving sherpas (7970 +/- 917m vs 6894 +/- 1195m,
53 $p = 0.0003$). Most climbers (76.5%) died on summit day, while most sherpas (82.2%) died during
54 route preparation. Climber mortality during summit descent on the standard routes during spring
55 1982-2006 versus 2007-2024 decreased from 3.0% to 0.8%, $p < 0.0001$. The spring summit
56 descent mortality for 2007 to 2024 was higher amongst climbers than sherpas (0.8% vs 0.1%,
57 $p < 0.0001$).

58 **CONCLUSION:** Mortality rates have decreased on Everest, but further improvements in safety
59 at extreme altitude may be possible.

60

61

62 **ABSTRACT FIGURE LEGEND:** *Deaths of climbers and sherpas on standard routes during*
63 *spring climbing seasons 2007-2024.* Most climbers (76.5%) died on summit day, while most
64 sherpas (82.2%) died during route preparation. The mortality during descent from the summit
65 was higher amongst climbers than sherpas (0.8% vs 0.1%, $p < 0.0001$). The mean altitude of fatal
66 incidents involving climbers was higher than those involving involving sherpas (7970 +/- 917m
67 vs 6894 +/- 1195m, $p = 0.0003$).

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69

70 **INTRODUCTION**

71 Mount Everest (8850m above sea level) is the highest point on earth. Atmospheric pressure at the
72 summit is approximately one-third of that at sea level, resulting in a hypobaric hypoxic
73 environment. The peak has attracted mountaineers for over a century, and for over a century,
74 mountaineers have died on its slopes. (Huey and Eguskitza 2001, Huey, Eguskitza et al. 2001,
75 Huey, Salisbury et al. 2007, Firth, Zheng et al. 2008, Westhoff, Koepsell et al. 2012, Huey,
76 Carroll et al. 2020, Salisbury, Hawley et al. 2021, Hawley and Salisbury 2025) Despite the
77 danger, increasing numbers of people have attempted to climb the mountain in recent years. And
78 in recent years, fatalities have continued to occur regularly.

79 A previous study of deaths of Everest between 1921 and 2006 found a dichotomous pattern of
80 mortality. (Firth, Zheng et al. 2008) Climbers tended to perish at extreme altitudes on summit
81 day, often during descent, while hired porters or guides (typically referred to as sherpas) were
82 often killed by objective hazards at lower altitudes during route preparation. Mortality during
83 descent from the summit via all routes was significantly higher for climbers than for sherpas
84 (2.7% v 0.4%).

85 Since the previous mortality study of the period up to 2006,(Firth, Zheng et al. 2008) climbing
86 on Everest has evolved. Most attempts to climb the mountain are now made during the spring
87 season along the standard routes, many as part of commercially-run expeditions. The routes are
88 protected by fixed ropes, the availability of weather forecasts has improved, and clothing,
89 expedition logistics, and oxygen delivery systems have evolved. We wondered if these changes
90 were associated with altered patterns of mortality. We therefore conducted an updated study to
91 compare mortality patterns from 2007-2024 with 1921-2006.

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94 **METHODS**

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96 We conducted a retrospective observation study of all Everest expeditions in which
97 mountaineers climbed above Base Camp (Base Camp on the South Side/Nepal, Advanced Base
98 Camp on the North Side/Tibet). We hypothesized that the climber mortality rate during descent
99 from the summit along the standard routes in the spring season has decreased in recent years,
100 2007 to 2024, compared to prior years, 1982 to 2006.

101

102 We replicated methods and definitions used previously.(Firth, Zheng et al. 2008) Briefly, data
103 were extracted from the Himalayan Database. Details of deaths were obtained from the
104 Database, internet press reports or posts, or communication with expedition members. For the
105 period 1921-2006, we used data generated from the prior Database extraction and analysis (Firth,
106 Zheng et al. 2008); for the period 2007-2025, we used data extracted from the updated 2025
107 Database version.(Hawley and Salisbury 2025) The altitude of death was defined as the altitude
108 at which a fatality occurred or was estimated to have occurred, or from which point a climber
109 was evacuated. A fatal incident was an event causing one or more deaths.

110 Four researchers (PF, JW, AS, CI) independently examined the accounts of deaths and classified
111 the deaths into mutually exclusive categories using prior methods and definitions. (Firth, Zheng
112 et al. 2008) Deaths were categorized as trauma (objective hazards of avalanche, icefall collapse,
113 or crevasse collapse, or a fatality involving a fall), non-trauma (high-altitude illness,
114 hypothermia, sudden death, or unclassified illness if a specific cause could not be identified),
115 disappeared (death not witnessed, body not found), or insufficient account (no account). (Figure
116 1) Disagreements on classification of deaths were resolved by consensus.

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123 ***Figure 1. Himalayan mortality classification.***

124

125 *Statistical analysis*

126 We used the Fleiss' kappa method to analyze the interrater agreement for classification of death
127 at the category level of trauma, non-trauma, disappeared, or insufficient account.(Fleiss 1971)

128 Binary and categorical outcomes were analyzed with χ^2 test or Fisher's exact test; continuous
129 outcomes with two-sided t test or Wilcoxon rank-sum test. Summit descent mortality rates were
130 the primary outcome. Analyses were performed using SAS version 9.4 (SAS Institute, Inc., Cary,
131 NC).

132

133 *Weather analysis*

134 We examined fatality accounts for mention of adverse weather as a contributing factor to deaths.

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139 **RESULTS**

140 From 1921 to 2024, 30385 mountaineers climbed above Base Camp, 14138 (46.5%) from 1921
141 to 2006, and 16247 (53.5%) from 2007 to 2024. (Table 1). The mean age of climbers (1921-2006
142 vs. 2007-2024) increased from 36.5 +/-8.9 years to 41.3+/-11.0 years, $p < 0.0001$. As in the prior
143 Database data extraction,(Firth, Zheng et al. 2008) data on sherpa ages were unreliable.

144 Everest has been summited 12881 times: 3058 (23.7%) ascents from 1921 (first ascents, 1953) to
145 2006, and 9823 (76.3%) ascents in years 2007 to 2024. (Table 1) Of all 12881 summits, there
146 were 12352 (95.9%) ascents via the standard routes in the spring season from 1982 to 2024, and
147 529 (4.1%) ascents via other routes or during other seasons. Of the 529 other ascents, 117 (0.9%)
148 were ascents via all routes from 1953 to 1981 (94 climbers, 23 sherpas), 401 (3.1%) were ascents
149 via other routes beside the standard routes or during other seasons from 1982 to 2006 (279
150 climbers, 122 sherpas), and 11 (0.1%) were spring ascents via non-standard routes from 2007-
151 2024 (7 climbers, 4 sherpas).

152

153

154 **Table 1. Population of mountaineers climbing above base camp, and summit ascents, on**
155 **Everest 1921-2006, and 2007-2024.** *Refers to the years 1982-2006, standard routes. **Refers
156 to all other ascents – all ascents from 1953 to 2006, and ascents between 1982 and 2006 via non-
157 stand routes.

158

159

Variable	Climbers 1921-2006	Sherpas 1921-2006	Climbers 2007-2024	Sherpas 2007-2024	Total 1921 -2024
Above BC					
Gender					
Male	7404 (92.2%)	6106 (99.9%)	6087 (83.6%)	8964 (99.9%)	28561 (94.0%)
Female	626 (7.8%)	2 (0.1%)	1191 (16.4%)	5 (0.1%)	1824 (6.0%)
Total	8030	6108	7278	8969	30385
Summit ascent					
Route /season					
Standard south spring	663 (37.5%)*	661 (51.2%)*	3302 (73.2%)	4137 (77.9%)	8763 (68.0%)
Standard north spring	732 (41.4%)*	484 (37.5%)*	1204 (26.7%)	1169 (22.0%)	3589 (27.9%)
Other routes/seasons**	373 (21.1%)**	145 (11.2%)**	7 (0.2%)	4 (0.1%)	529 (4.1%)
Total Ascents	1768	1290	4513	5310	12881

160

161

162 There were 309 deaths, 192 (63.78%) from 1921 to 2006, and 117 (38.87%) from 2007 and
163 2024. (Table 2) The overall mortality rate decreased from 1921 to 2006 versus 2007 to 2024,
164 1.4% (n=192/14138) vs. 0.7% (n=117/16247), $p<0.001$. The mortality rate decreased for
165 climbers, 1.6% (n=125/8030) vs. 1.0% (n=73/7278), $p=0.002$, and for sherpas 1.1% (n=67/6108)
166 vs. 0.5% (n=45/8968), $p<0.001$.

167 The classification of deaths is reported in Table 2. Details from the earlier period 1921 to 2006
168 have been described previously. (Firth, Zheng et al. 2008) There were 87 fatal incidents resulting
169 in 117 deaths from 2007 onwards. The primary sources of accounts of the incidents were
170 internet-based reports (77), Himalayan Database notes (5), direct communications with
171 expeditions (3), and no accounts (2). The kappa value for agreement on classification of the 117
172 deaths from 2007 to 2024 was 0.70 (substantial agreement). (Fleiss 1971)

173

174

175 *Table 2. Classification of deaths of mountaineers climbing above base camp, 1921-2006, and*
 176 *2007-2024.*

177

Classification	Climbers 1921- 2006	Sherpas 1921- 2006	Total 1921- 2006	Climbers 2007- 2024	Sherpas 2007- 2024	Total 2007- 2024	Total 1921- 2024
Trauma	54 (43.2%)	59 (88.0%)	113 (58.9%)	9 (12.5%)	32 (71.1%)	41 (35.0%)	154 (49.8%)
Objective hazard	20	47	67	5	27	32	98
Falls	34	12	46	4	5	9	57
Non-trauma	46 (36.8%)	6 (9.0%)	52 (27.1%)	56 (77.7%)	10 (22.2%)	66 (56.4%)	118 (38.2%)
High altitude illness	12	5	17	13	2	15	33
Hypothermia	11	0	11	0	0	0	11
Sudden death	7	0	7	6	4	10	17
Unclassified	16	1	17	37	4	41	58
Disappeared	25 (20.0%)	2 (3.0%)	27 (14.1%)	5 (6.9%)	3 (6.8%)	8 (6.7%)	35 (11.3%)
No account	0 (0%)	0 (0%)	0 (0%)	2 (2.7%)	0 (0%)	2 (1.7%)	2 (0.6%)
Total deaths	125	67	192	72	45	117	309
Mortality rate	1.6%	1.1%	1.4%	1.0%	0.5%	0.7%	1.0%

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179

180 Of deaths that occurred from 2007-2024, 96.6% (n=113/117) occurred on the standard routes,
181 and 3.4% (n=4/117) occurred on the technical routes, all during the spring climbing season. Of
182 the 113 deaths on the standard routes, 53.1% (n=60/113) occurred during or after summit day
183 attempt [climbers, 76.5% (n=52/68), sherpas 17.7% (n=8/45)], while 46.9% (n=53/113) occurred
184 before summit day attempts [climbers 23.5%, n=16/68, sherpas 82.2%, n=37/45). Of the total 87
185 fatal incidents, 84 occurred on the standard routes. The mean altitude of fatal incidents on the
186 standard routes involving climbers was higher than those involving sherpas: 7970 +/- 917m
187 (n=64) vs. 6894 +/- 1195m (n=25), p=0.0003)

188 Figure 2 shows the distribution of climber and sherpa deaths during the spring climbing season,
189 on the standard routes, plotted against altitude and stage of the expedition (route
190 preparation/ascent versus descent from summit) from 2007 to 2024. Additional plots of mortality
191 are presented in Figures 3-5.

192

193

194 **Figure 2. Deaths of climbers and sherpas on standard routes during spring climbing seasons**
195 **2007-2024.** Climber fatalities are marked with a solid triangle; sherpa fatalities are marked with
196 a solid circle. Deaths during descent from the summit are plotted above the route profile at the
197 altitude at which death occurred; deaths before summiting or during summit bids with unknown
198 outcomes are plotted below the route profile at the altitude at which death occurred. The boxed
199 insert shows deaths that occurred before summitting (i.e., those that are plotted below the route
200 profile just short of the summit). The right axis shows estimated barometric pressure and
201 estimated ambient air temperature during May. The scale on x axis is expanded by factor of two
202 for the route above 8000 m.

203

204 **Figure 3 Deaths of climbers on standard routes during spring 1982-2024.** Climber fatalities from
205 1982 to 2006 are marked with a hollow triangle; climber fatalities from 2007 to 2024 are
206 marked with a solid triangle. Deaths during descent from the summit are plotted above the route
207 profile at the altitude at which death occurred; deaths before summiting or during summit bids
208 with unknown outcomes are plotted below the route profile at the altitude at which death
209 occurred. The boxed insert shows deaths that occurred before summitting (i.e., those that are
210 plotted below the route profile just short of the summit).

211

212 **Figure 4 Deaths of sherpas on standard routes during spring 1982-2024.** Sherpa fatalities from 1982
213 to 2006 are marked with a hollow circle; sherpa fatalities from 2007 to 2024 are marked with a
214 solid circle. Deaths during descent from the summit are plotted above the route profile at the
215 altitude at which death occurred; deaths before summiting or during summit bids with unknown
216 outcomes are plotted below the route profile at the altitude at which death occurred. The boxed
217 insert shows deaths that occurred before summitting (i.e., those that are plotted below the route
218 profile just short of the summit).

219

220 **Figure 5 Deaths of climbers and sherpas on standard routes during spring 1982-2024.** This plot
221 combines all sherpa and climber deaths from 1982 to 2024. Sherpa fatalities are marked with a
222 hollow (1982-2006) or solid (2007-2024) circle; climber fatalities are marked with a hollow
223 (1982-2006) or solid (2007-2024) triangle. Deaths during descent from the summit are plotted

224 *above the route profile at the altitude at which death occurred; deaths before summiting or*
225 *during summit bids with unknown outcomes are plotted below the route profile at the altitude at*
226 *which death occurred. The boxed insert shows deaths that occurred before summitting (i.e.,*
227 *those that are plotted below the route profile just short of the summit).*

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230

231 Table 3 shows the classification of deaths that occurred in mountaineers who climbed above
232 8000m. Details of deaths between 1921 and 2006 have been described previously.(Firth, Zheng
233 et al. 2008) From 2007 to 2024, 51.3% (n=60/117) of deaths occurred after mountaineers climbed
234 above 8000m [71.2% (n=52/73) climbers; 18.1% (n=8/44) sherpas.] Of these 60 deaths, 40
235 (66.7%) were of mountaineers descending from the summit, 20 (33.3%) of were mountaineers
236 making unsuccessful attempts or with unknown summit outcomes.

237 **Table 3. Classification of deaths that occurred in mountaineers who climbed above 8000m.**

238

Category	Climbers 1921- 2006	Sherpas 1921- 2006	Total 1921 -2006	Climbers 2007- 2023	Sherpas 2007- 2024	Total 2007- 2024	Total 1921- 2024
Trauma	26 (31.7%)	9 (75.0%)	35 (37.2%)	3 (5.8%)	1 (25.0%)	4 (6.7%)	39 (28.3%)
Fall	23	9	32	3	1	4	36
Objective hazard	3	0	3	0	0	0	3
Non-trauma	31 (37.8%)	1 (8.3%)	32 (34.0%)	44 (84.6%)	4 (50.0%)	48 (80.0%)	80 (58.0%)
High altitude illness	11	0	11	8	0	8	19
Hypothermia	2	0	2	0	0	0	2
Sudden death	5	0	5	3	1	4	9
Unclassified	13	1	14	33	3	36	50
Disappeared	25 (30.5%)	2 (16.7%)	27 (28.7%)	5 (9.6%)	3 (37.5%)	8 (13.3%)	29 (21.0%)
Total	82	12	94	52	8	60	138

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Table 4 show mortality rates during descent down the standard routes during the spring climbing season, for the periods 1982 to 2006, and 2007 to 2024. As in previous years, the descent mortality for 2007 to 20024 remained higher amongst climbers than sherpas: 0.8% (n=35/4506) vs 0.1% (n=5/5306), p<0.0001.

Table 4. Mortality rates during descent from the summit on the standard north (Tibet) and south (Nepal) routes during the spring season.

Route	Mountaineers	Descent mortality rate 1982-2006 % (n/N)	Descent mortality rate 2007-2024 % (n/N)	P value
North	Climbers	3.6 (26/732)	0.7 (9/1204)	P<0.0001
	Sherpas	0 (0/484)	0.1 (1/1169)	P=0.52
	All Mountaineers	2.1 (26/1216)	0.4 (10/2373)	P<0.0001
South	Climbers	2.0 (13/663)	0.8 (26/3302)	P=0.005
	Sherpas	0.5 (3/661)	0.1 (4/4137)	P=0.03
	All Mountaineers	1.2 (16/1324)	0.4 (30/7439)	P=0.0002
Combined routes	Climbers	3.0 (42/1395)	0.8 (35/4506)	P<0.0001
	Sherpas	0.3 (3/1145)	0.1 (5/5306)	P=0.16
	All Mountaineers	1.8 (45/2540)	0.4 (40/9812)	P<0.0001

Weather related deaths

Weather may have played a direct role in one death, when an unroped climber who sustained an unwitnessed fatal fall may have been blown off the route by a gust of wind. We did not detect a primary role of weather deterioration in other accounts, although inclement conditions complicated one unsuccessful rescue attempt of an incapacitated climber.

260 **DISCUSSION**

261 We compared the mortality patterns on Mount Everest of the periods 1921 to 2006 with 2007 to
262 2024. Mortality rates amongst all mountaineers climbing above Base Camp decreased from 1.4%
263 to 0.7%, $p < 0.001$. Climber mortality during summit descent on the standard routes during spring
264 decreased from 3.0% to 0.8%, $p < 0.0001$.

265 As in previous years, climbing at extreme altitude was very dangerous - more than three-quarters
266 of climber deaths occurred on summit day, frequently during descent from the peak.(Figure 2,3)
267 The summit phase of the climb occurs in extremely low barometric pressures, which produce
268 profound arterial hypoxemia ; a field study of climbers near the summit measured mean arterial
269 oxygenation of 24.6 mmHg (3.28 kPa).(Grocott, Martin et al. 2009) While physiological
270 adaptation can preserve cerebral(Wilson, Edsell et al. 2011) and peripheral oxygen
271 delivery,(Sutton, Reeves et al. 1988, Grocott, Martin et al. 2009) inadequate acclimatization can
272 lead to progressive neurological impairment.(Wilson, Newman et al. 2009) This presents with
273 impaired effort tolerance, motor incoordination, and decreased consciousness – deficits that, on
274 the summit ridges, are associated with separation from climbing parties, fatal falls, and
275 progressive incapacity leading to death.(Pollard and Clarke 1988) (Firth, Zheng et al. 2008)

276 Compared to earlier years, however, mortality patterns above 8000m have changed. (Table 3)
277 Deaths associated with falls decreased, as did the number of mountaineers who disappeared
278 before dying. The standard routes are now secured to the summit with regularly maintained fixed
279 ropes, reducing the risk of fatal falls. The decrease in climbers who die after disappearing may in
280 part be due to a classification artefact: as more people are now climbing above 8000m (Table 1),
281 a greater proportion of deaths are witnessed. However, it may also arise from improved
282 cooperation, with mountaineers now recognizing the danger of a team member falling behind the
283 group. Early identification and rescue of stragglers may have contributed to the lower descent
284 mortality rates.

285 Other factors may also have contributed to reduced mortality above 8000m. Improved
286 acclimatization schedules and better oxygen delivery systems could decrease the incidence of
287 altitude illness. Improved access to weather predictions, lighter and warmer clothing, a greater
288 appreciation of the dangers of wind chill (Huey and Eguskitza 2001, Moore and Semple 2011,
289 Szymczak, Marosz et al. 2021), and better hydration and nutrition may lessen the dangers of

290 adverse weather, exhaustion and hypothermia. Advances in logistical support - more effective
291 telecommunication devices, improved rescue capacity at higher altitudes, and commercial
292 expedition operators providing greater professional sherpa support of climbers - could also
293 contribute.

294 Although recent mortality has decreased, a stark discrepancy persists: climbers died during
295 summit descent at eight times the rate of sherpas (0.8% vs 0.1%, $p < 0.0001$) (Table 4). While this
296 variation may relate to differences between the two populations of mountaineers, (Firth, Zheng et
297 al. 2008) the disparity may also suggest further safety improvements at extreme altitude remain
298 possible.

299
300 The most frequent category of deaths above 8000m was non-traumatic unclassified causes. The
301 frequency of this classification stemmed in part from the lack of detail of many accounts, which
302 precluded a specific medical diagnosis. However, it also reflects the difficulty of definitively
303 attributing primary cause to non-specific symptoms of extreme exhaustion and decreased level of
304 consciousness – frequent symptoms noted in these cases. Alone or in combination, evolving
305 altitude illness and hypoxemia, dehydration, inadequate energy intake, severe fatigue, and
306 hypothermia may contribute to profound impairment and subsequent progression of underlying
307 problems.

308 Rescuing impaired climbers at extreme altitude is exceedingly difficult and frequently
309 impossible. Persistent high death rates at extreme altitude, despite route rope protection and
310 larger climbing groups, reflects in part the inability or failure to rescue debilitated climbers.
311 Avoidance of exhaustion-associated impairment through better assessment of acclimatization
312 prior to summit attempts, as well as early identification of evolving problems during ascent, may
313 be a key priority for mitigating persistent excess mortality.

314 For employed mountaineers, the Khumbu Ice Fall on the Nepal side continued to be the most
315 dangerous part of the mountain (Figure 2, 4). Many deaths occurred in multiple casualty
316 incidents from massive avalanches. While fewer trauma-related deaths contributed to overall
317 decreased mortality amongst sherpas (Table 2), they are disproportionately at risk from objective
318 hazards due to greater cumulative exposure. (Firth, Zheng et al. 2008) Risks may increase in the

319 future as glaciers and snowpack become less stable with climate change.(Moore, Cristofanelli et
320 al. 2017, Moore, Cristofanelli et al. 2020),

321 Minimizing the number of trips through the icefall, limiting equipment loads, promoting safety
322 practices of continuous use of rope protection, as well as encouraging climbers to carry more of
323 their own equipment *en route* to the summit, might decrease the risk to sherpas. Nevertheless,
324 deaths from unsurvivable avalanches or ice fall collapses may remain an unavoidable hazard of
325 this part of the route. This raises ethical questions of employing people for dangerous jobs in
326 pursuit of a sporting goal. (Largent 2014) Five concerns that routinely arise in these debates are
327 those of adverse risk-benefit ratios, undue inducement, coercion, exploitation, and effects of
328 potential safety measures. Appropriate compensation, life insurance, and maximizing safety
329 measures would moderate potentially unethical exposure of employees to risk.

330
331 Limitations of this study include a lack of precise accounts of many extreme-altitude deaths, and
332 the inherent difficulty of assigning a single cause of death to complex situations. Our descriptive
333 mortality classification system was designed for high validity and consistency, rather than
334 attempting to identify the most prominent cause of death. Future work might include improved
335 reporting of fatal incidents, to better identify avoidable contributors to fatalities. Closer clinical
336 reports, as well as experimental work, could improve understanding of pathology at extreme
337 altitude. The strengths of the study include the size and accuracy of the Himalayan
338 Database,(Hawley and Salisbury 2025) built by decades of dedicated work by Elizabeth Hawley,
339 Richard Salisbury, and many others.

340
341 In conclusion, while mortality rates have dropped in association with modern changes in
342 climbing techniques, Everest remains an extremely dangerous place. A heightened awareness of
343 the persistent patterns of mortality may contribute to the avoidance of fatal complications.

344

345

346 **Additional Information.**

347 Data are available without charge from the Himalayan Database. (Hawley and Salisbury 2025).

348 Results of the analysis of individual deaths are available on request.

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