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7 **Corresponding author:** Major Cody Butler  
8 40 Old Kent Rd  
9 Mansfield, CT 06250  
10 [Cody.butler@uconn.edu](mailto:Cody.butler@uconn.edu); 435-650-2445

11  
12 **Title:** Deaths among U.S. Air Force basic military trainees, 2008-2020

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14 **Mailing address of each author:**

15 Major Cody R. Butler, US Air Force, Biomedical Science Corps (active duty)  
16 Air Force Institute Technology  
17 2950 Hobson Way, Wright-Patterson AFB, OH 45433

18 Major Korey B. Kasper, US Air Force, Medical Corps (active duty)  
19 559<sup>th</sup> Trainee Health Squadron  
20 JBSA-Lackland, TX 78236

21 Robert A. Huggins  
22 Korey Stringer Institute, University of Connecticut  
23 2095 Hillside Rd U-1110, Storrs CT 06269

24 Colonel Thomas Leo Cropper, US Air Force, Biomedical Science Corps (retired)  
25 559<sup>th</sup> Trainee Health Squadron  
26 JBSA-Lackland, TX 78236

27  
28 Major Dianne N. Frankel, US Air Force, Medical Corps (active duty)  
29 559<sup>th</sup> Trainee Health Squadron  
30 JBSA-Lackland, TX 78236

31  
32 Major Mary T. Pawlak, US Air Force, Medical Corps (reserve)

33 559<sup>th</sup> Trainee Health Squadron  
34 JBSA-Lackland, TX 78236  
35  
36 Brigadier General Theresa Casey, US Air Force, Medical Corps (retired)  
37 559<sup>th</sup> Trainee Health Squadron  
38 JBSA-Lackland, TX 78236  
39  
40 Douglas J. Casa  
41 Korey Stringer Institute, University of Connecticut  
42 2095 Hillside Rd U-1110, Storrs CT 06269

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54

55 **Abstract**

56 **Introduction:** United States Air Force (USAF) Basic Military Training (BMT), a rigorous training  
57 program for all enlisted members of the USAF, trains roughly 36,000 recruits annually. For  
58 some, that training has come at a high cost. While the average death rate at USAF BMT have  
59 decreased between 1956 and 2007 due to process improvement and preventive medicine  
60 efforts, further review is warranted to examine the deaths that have occurred since the last  
61 published period (1997-2007) and to determine the impact policy changes and updates have  
62 had on deaths rates since that time. Therefore, the purpose of this paper is to identify death  
63 rates and types from 2008-2020, explore policy implementation, and identify areas needing  
64 further improvement or modifications to the overall safety, fitness, and health of USAF BMT  
65 trainees.

66 **Materials and Methods.** All deaths were examined and reviewed from 2008 through 2020 for  
67 trainees attending the USAF BMT using medical records and autopsy reports. Death rates were  
68 calculated using the total population of trainees in a given year as well as over the entire 13-  
69 year study period.

70 **Results.** From 2008 to 2020, five deaths occurred among USAF BMT trainees (one cardiac, two  
71 exertional sickling due to sickle cell trait, one infection and one suicide). This resulted in an  
72 overall average death rate of 1.08 per 100,000 trainees, as compared to 1.46 per 100,000 from  
73 1997-2007. The last death in the study period occurred in 2016.

74 **Conclusion.** A modest downward trend of average death rate has continued since 2007, and no  
75 deaths from 2016 through 2020 represents the longest time-frame without any deaths at USAF  
76 BMT over all times reported (dating back to 1956) which suggest that emergency best practice

77 policies are/have improved. However, cardiac death rate and suicide rate have not changed  
78 since the last report. Policies and practices should be continuously reviewed and refined to  
79 reduce the risk of death at USAF BMT.

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81

82 **Introduction**

83 United States Air Force (USAF) Basic Military Training (BMT) is the entry-level program  
84 for all enlisted Airmen. USAF BMT trains roughly 35,000 recruits annually<sup>1</sup> on Joint Base San  
85 Antonio (JBSA) - Lackland, Texas, where the hot southern climate combined with intense  
86 physical training among trainees from a wide range of climate zones and fitness backgrounds  
87 creates an environment historically shown to present a risk of training-related deaths. Since the  
88 1950s, commitment to ongoing policy improvements based on health-related surveillance has  
89 proven effective in the optimization of the health and safety of trainees.<sup>2,3</sup>

90 To date, two published reports have analyzed the death rate at USAF BMT. The first,  
91 which reviewed 40 years of data (1956 to 1996) reported 85 deaths, with an average death rate  
92 of 2.8 per 100,000 trainees.<sup>2</sup> The second investigation by Venuto et al.<sup>3</sup> examined non-  
93 traumatic deaths over the subsequent ten year period (1997-2007). The five reported deaths  
94 showed an average non-traumatic death rate of 1.2 per 100,000 recruits. Although the average  
95 death rate decreased in the 1997-2007 period compared to the 1956-1996 period, ongoing  
96 review is warranted to reassess the continuation of that downward trend, and to investigate  
97 the causes and patterns of deaths, specifically those related to training policies and practices.  
98 Therefore, the purpose of this paper is to identify annual and cumulative death rates and  
99 causes from 2008-2020 and to explore opportunities for improvement to the safety and health  
100 of trainees at USAF BMT.

101 **Methods**

102 Deaths of USAF BMT trainees from 2008 through 2020 were reviewed. Data sources included  
103 military electronic medical records and autopsy reports (as available). The Air Force Mortality

104 Registry was used to confirm cause of death (as able). Where applicable, causes of death were  
 105 categorized in accordance with previous literature,<sup>4</sup> including cardiac, infectious disease and  
 106 vascular. Death rates were calculated based on the total population of trainees for the  
 107 respective year, as well as an overall cumulative value for the study period.

108 **Results**

109 From 2008 to 2020, there were five trainee deaths in USAF BMT. Causes reported as: one  
 110 cardiac-origin, two exertional sickling (ES) with sickle cell trait (SCT), one infection, and one  
 111 suicide (see **Table 1**), with a combined average death rate of 1.08 per 100,000 trainees. In  
 112 addition, as of the time of this writing, no deaths had occurred since 2016, constituting the  
 113 longest period of time without a trainee fatality at USAF BMT.

**Table 1 . USAF BMT Total Accessions and Mortality Rate (2008-2020)**

Year	Total BMT Accessions (n)	Total BMT Deaths (n)	Death Occurrence	Mortality Rate (per 100,000 Accessions)
2008	34,188	0	-	-
2009	38,901	0	-	-
2010	36,096	1	Suicide	2.8
2011	36,226	2	ES with SCT; infection	5.5
2012	37,287	0	-	-
2013	34,736	0	-	-
2014	31,525	1	ES with SCT	3.2
2015	34,572	1	Cardiac	2.9
2016	37,625	0	-	-
2017	37,098	0	-	-
2018	36,647	0	-	-
2019	39,930	0	-	-
2020	27,252*	0	-	-
Total	462,074	5	-	1.08

\*Due to COVID-19, BMT was condensed from 8.5 weeks to 7.5 weeks with reduced number of trainees.

114

115 *Case 1. Suicide: asphyxiation by hanging*

116 A 26-year old male trainee died in December 2010. The cause of death was suicide by hanging  
117 in the dorm room using a military issue strap. No preceding medical records indicated a history  
118 or report of any mood disorder or mental health concerns.

119 *Case 2. Infection: Adenovirus encephalitis*

120 A 22-year old female trainee died in June 2011. The trainee experienced symptoms for one  
121 week prior to being dispensed a “cold pack” (acetaminophen, benzocaine and menthol  
122 lozenges, ibuprofen, and pseudoephedrine) by the independent duty medical technician  
123 (IDMT); the following day, she was assisted back into to the IDMT dispensary by a military  
124 training instructor (MTI) for trouble walking (fell the previous day) and fever. An ambulance  
125 transported the trainee to the emergency department where she was disoriented and  
126 decreasingly arousable. After a lumbar puncture and dose of acyclovir were completed, she  
127 was transferred to the intensive care unit where her condition continued to deteriorate. Brain  
128 MRI revealed findings consistent with encephalomyelitis from which the trainee never  
129 recovered. The cause of death was encephalomyelitis due to adenovirus 4.

130 *Case 3. Hematologic: Exertional collapse associated with Sickle Cell Trait (ECAST)*

131 A 26-year old male trainee died in October 2011. The previous month, the trainee had tested  
132 positive for SCT (Hgb S 41.1%) and was provided a standardized SCT brief by the Trainee Health  
133 Clinic regarding risks, signs, symptoms and precautions. The trainee had previously denied any  
134 past history of cardiac or exercise-related symptoms during his Military Entrance Processing  
135 Station (MEPS) physical exam prior to shipping to BMT. The trainee collapsed during physical

136 exertion and resuscitations attempts proved unsuccessful. The cause of death was cardiac  
137 dysrhythmia due to acute vaso-occlusive crisis from SCT exacerbated by physical exertion.

138 *Case 4. Hematologic: Exertional collapse associated with Sickle Cell Trait (ECAST)*

139 A 19-year old male trainee died in February 2014. During the first week of training, he reported  
140 to the medical facility reporting symptoms of fatigue, lightheadedness and nausea following  
141 physical training (running) that morning. He admitted he had not exercised much prior to BMT  
142 but denied trouble with sports in high school (he had also reported no issues with exercise or  
143 prior cardiac conditions on his MEPS exam). The trainee was given a physical training waiver to  
144 exercise at a self-selected pace for a week and educated on the importance of proper hydration  
145 and stretching. The next day, he reported back to the medical clinic and stated that he could  
146 not run because his legs and lungs burned whenever he tried. He was assigned to BMT Medical  
147 Hold (removed from training for health reasons). However, the following day he was returned  
148 to training with no restrictions so that he could take a fitness assessment which would dictate  
149 whether the trainee would be sent home for poor fitness. That afternoon, while performing the  
150 1.5 mile run, the trainee collapsed to the ground, going from agitated and restless to  
151 unconscious. The on-site IDMT had concerns for moderate dehydration and started an IV prior  
152 to calling an ambulance. That night in the hospital, he went into cardiac arrest, and  
153 resuscitation efforts were unsuccessful. Hemoglobin (Hgb) screening lab results, collected a  
154 week prior, returned the same day the trainee collapsed, revealing the trainee to have SCT. As  
155 such, the trainee (and medical staff) were unaware of his SCT status at the time of death. The  
156 cause of death was ES as a complication of SCT.

157 *Case 5. Cardiac*

158 A 19-year old female trainee died in May 2015. She collapsed while running during physical  
 159 training and went into cardiac arrest. CPR was initiated by on-site IDMT; automated external  
 160 defibrillator (AED) identified ventricular fibrillation, which, after four shocks, converted to  
 161 pulseless ventricular tachycardia while en route to the emergency department, where further  
 162 resuscitation efforts failed. An anomalous coronary artery was found to be the cause of death.  
 163 Of note, the trainee reported no issues with exercise or prior cardiac conditions on her MEPS  
 164 exam, and her cardiac exam during MEPS was normal.

165 **Discussion**

166 The death rate per 100,000 trainees has continued a downward trend previously demonstrated  
 167 from the 1997-2007 review. **Table 2** provides a visual comparison of each time period to  
 168 provide death rates of traumatic, non-traumatic and exertional (where applicable).

**Table 2 . Death Rate Comparisons of USAF BMT**

Cause of Death	1956-1996 (n=85)		1997-2007 (n=6)		2008-2020 (n=5)	
	Death, n (%)	Death Rate (per 100,000)	Death, n (%)	Death Rate (per 100,000)	Death, n (%)	Death Rate (per 100,000)
Cardiac	30 (35%)	1.00	3 (50%)	0.70	1 (20%)	0.20
Heat Stroke	6 (7%)	0.20	1 (17%)	0.20	0 (0%)	0.00
Exertional Sickling with SCT	Not specified	0.00	0.0	0.00	2 (40%)	0.40
Suicide	11 (13%)	3.20	1 (17%) <sup>5</sup>	0.20	1 (20%)	0.20
Infection	28 (33%)	0.90	1 (17%)	0.20	1 (20%)	0.20
Overall death	85	2.80	6	1.46	5	1.08
Non-traumatic death	39 (46%)	2.10	2 (33%)	1.20	2 (40%)	0.90
Exertion-related death	36 (42%)	1.19	4 (67%)	0.98	3(60%)	0.60

169 SCT (sickle cell trait)

170 **Exertional Sickling in SCT**

171 Two of the five deaths at USAF BMT from 2008-2020 were due to sickling red blood  
 172 cells, which occurs most frequently in those carrying a sickle Hgb gene during times of cellular  
 173 stress (oftentimes from exercise). During the 1956-1996 analysis, of the 85 deaths, seven had  
 174 SCT, and five of these fatalities were potentially related to SCT status. Thus, the relative risk for

175 nontraumatic deaths for expected SCT during that time-period was 23.53 times higher than  
176 non-SCT populations.<sup>2</sup> At the time, knowledge regarding effects of SCT was scarce, and,  
177 notably, it was the US military during the late 1980s that first linked SCT to BMT sudden death  
178 during exercise.<sup>5</sup> Since then, all recruits are screened for disqualifying Hgb disorders within the  
179 Air Force.<sup>6</sup> Currently, strenuous fitness training is limited during the initial 10 days, in part to  
180 allow for identification/education of trainees with SCT and to facilitate acclimatization for those  
181 who arrive from cooler climates.

182           Recruits who screen positive for sickle cell (trait or disease), are restricted from normal  
183 fitness activities until electrophoresis can distinguish SCT from sickle cell disease, which usually  
184 takes a week. As sickle cell disease (HbS concentrations >45%) is a disqualifying condition,  
185 these individuals are removed from training and discharged from the military. All trainees  
186 identified as SCT are required to receive a briefing on the associated risks, risk factors, universal  
187 precautions, and warning signs of a sickling event. At the end of this briefing, the trainee may  
188 either opt out of the Air Force or provide informed consent to proceed in training. Trainees  
189 opting to continue are issued a red medical alert tag to wear to help first responders identify  
190 the trainee as SCT in the event of a sickling crisis to facilitate proper intervention.<sup>7</sup>

191           In 2014, following the second death of a SCT trainee during this study period, a position  
192 was created for an active duty sports medicine physician in part to help guide BMT efforts to  
193 decrease additional SCT and exertion-related deaths. This led to the development and  
194 expansion of a multi-disciplinary sports medicine program at JBSA-Lackland to improve the  
195 health, fitness and safety of the trainees. As of the time of this writing, this “integrated

196 operational support” (IOS) includes sports medicine physicians, athletic trainers (ATs), exercise  
197 physiologists, and registered dietitians.

### 198 **Exertional Rhabdomyolysis (ER) and Exertional Heat Stroke (EHS)**

199           Between 1956 and 1996, two of the seven SCT related deaths at the USAF BMT were  
200 diagnosed with ER, and two other deaths by ER were likely associated with EHS,<sup>2</sup> and thus a  
201 discussion on these exertion-related injuries, as well as their risks and the polices directed at  
202 their mitigation, is warranted.

#### 203 *Exertional Rhabdomyolysis*

204           Between 2015 and 2019, there were 70 cases of diagnosed ER at JBSA-Lackland,  
205 accounting for 2.7% of the total cases in the US military.<sup>8</sup> The current BMT fitness program was  
206 revamped in the summer of 2020 under joint guidance from, and collaboration with, the sports  
207 medicine physicians, physical therapists, and exercise physiologists and ATs. The adjustments  
208 were based on evidence-based fitness training principles of personalized load progressions,  
209 whole-body functional interval training, and varied workouts six days per week with a goal of  
210 reducing injury and improving fitness test success rates. Despite a rigorous fitness program with  
211 varied baseline trainee fitness levels upon arrival to USAF BMT, the current risk of sudden  
212 trainee death related to ER is extremely low.

#### 213 *Exertional Heat Stroke (EHS)*

214           The climate of JBSA-Lackland, TX is subtropical, warm-to-hot most of the year with high  
215 humidity (59% - 73% annual average),<sup>9</sup> so the potential for heat injury is high at USAF BMT,  
216 especially in trainees arriving from cooler climates who may be unacclimated to both the  
217 environmental heat and exercise regimen. Although previously identified as a fairly common

218 cause of death at BMT, during this study period of 2008-2020, there were zero EHS fatalities,  
219 thanks in part to steps USAF BMT has taken to minimize the risk of exertional heat illness (EHI),  
220 dating back to the late 1950s (see **Figure 1**). Efforts have included collaboration and specialized  
221 training with experts in EHI<sup>7</sup> to update and incorporate best practices regarding prevention,  
222 recognition and treatment of EHI, as well as embedding ATs to supervise conditioning.<sup>10</sup> In  
223 addition, the BMT physical fitness training program allows ten days of acclimatization prior to a  
224 maximum effort fitness test,<sup>11</sup> directs summer fitness activities to be done in the early morning  
225 to take advantage of lower temperatures and sun exposure, and mandates adherence to  
226 hydration schedules, Wet Bulb Globe Temperature (WBGT) Index, and associated work-rest  
227 protocols. Furthermore, the “cool first, transport second” approach to EHI management<sup>12</sup> is  
228 regularly reviewed and drilled with medical personnel, and ice immersion tubs are strategically  
229 positioned near training locations with ice sheets kept on hand in the field by personnel. Finally,  
230 each EHI that occurs is investigated by 37<sup>th</sup> Medical Wing Safety Office and 559<sup>th</sup> Medical Group  
231 Trainee Health Surveillance to identify causal factors and recommend additional  
232 countermeasures.<sup>13</sup> Clearly, these steps have helped prevent deaths due to EHS over the past  
233 13 years at USAF BMT.

#### 234 **Cardiac**

235         Although just one death of cardiac origin occurred at BMT over this study period,  
236 cardiac etiologies are the leading cause of sudden death overall amongst U.S. military basic  
237 training (all services).<sup>4,14</sup> Given both the high volume of a very physically diverse group of  
238 individuals that train each year and the high physical demands required in the military, the risk  
239 of cardiac-related deaths at USAF BMT persists. To that end, it is less than the incidence of

240 sudden cardiac death of high school and collegiate athletes (1.3 and 2 in 100,000 athletes,  
241 respectively) reported previously<sup>15</sup>. The pre-accession medical screen (history and physical  
242 examination) of all aspiring military members is intended to identify disqualifying cardiac  
243 conditions, yet its effectiveness is questionable<sup>16</sup> as there are conditions that may not have  
244 signs or symptoms (and are undetectable by history and physical examination alone) yet are  
245 disqualifying.<sup>17</sup>

246         Some cardiac conditions may potentially be detected by a screening electrocardiogram  
247 (ECG), but ECG was removed from the official US military accession screening in 2002, and has  
248 been noted to be of limited screening utility due to cost ineffectiveness, the high volume of  
249 screens needed to detect a disqualifying condition,<sup>3</sup> and validity and reliability concerns  
250 stemming from high variability of clinician interpretation (especially in athletic patient  
251 populations). These limitations may be reduced in the future, as advances in technology and  
252 ECG interpretation may warrant re-introducing ECG as part of the pre-accession screen.<sup>17</sup>  
253 Athlete-specific ECG screening criteria have been developed for collegiate athletes,<sup>18</sup> and a  
254 similar military-specific criteria may be adapted and incorporated into pre-screening.<sup>19</sup> While  
255 debate continues regarding the feasibility and effectiveness of pre-accession ECG,<sup>16,20-23</sup> it will  
256 likely never detect all potentially-fatal underlying cardiac pathologies (e.g. anomalous coronary  
257 artery). As such, due to the high risk of sudden cardiac death in the USAF BMT trainee  
258 population, all MTIs are certified in basic life support. Furthermore, IDMTs and ATs are present  
259 during all high intensity fitness training and testing sessions and are trained to respond quickly  
260 with CPR and an AED to a collapsed trainee.

## 261 **Respiratory Infection**

262 One trainee death from 2008-2020 was a result of infection (viral encephalitis due to  
263 adenovirus 4). Military training, which has trainees living and training in close quarters with the  
264 effects of fatigue, exertion, and stress causing impaired immune systems,<sup>24</sup> has historically been  
265 an environment with high risk of infectious disease spread. As such, upon entry in the military,  
266 trainees receive a host of vaccinations as well as a penicillin injection to prevent viral and  
267 streptococcal infections, respectively.

#### 268 *Adenovirus*

269 Live, oral vaccines for adenovirus serotypes 4 and 7 have been utilized (nearly  
270 exclusively) in the military since 1971, resulting in a >95% reduction in febrile respiratory illness  
271 (FRI) due to adenovirus.<sup>25</sup> However, the sole manufacturer ceased production of the vaccine  
272 and BMT trainees stopped receiving it in 1999, permitting re-emergence of this virus<sup>26-30</sup> which  
273 accounted for 68% of FRI thereafter in basic training environment.<sup>31</sup> In response, Trainee Health  
274 Surveillance, a preventive medicine team, was established to conduct disease surveillance,  
275 prevention and control, critical to minimizing health impact to the training population and lost  
276 training time.<sup>32</sup> Trainee Health Surveillance was able to identify sources of infection and  
277 recommend avenues for respiratory disease prevention.<sup>33</sup> Unfortunately, these efforts, in the  
278 absence of vaccination, were not enough to prevent the trainee death from adenovirus  
279 (serotype 4) encephalitis in June 2011. Later that same year, adenovirus vaccinations from a  
280 new manufacturer were administered to all basic trainees once again, which have again  
281 resulted in great reductions in illness.<sup>34</sup>

#### 282 **Suicide**

283           Although the suicide rate decreased from the initial review, the rate has been consistent  
284 since 1997. USAF BMT is, by design, a stress inoculation, at least partially intended to expose  
285 maladaptive behaviors and underlying mental health disorders unfitting for military service.  
286 Trainees demonstrating difficulty adapting to the USAF while in training will likely continue to  
287 struggle to adjust to operational careers in the USAF.<sup>35</sup> BMT curriculum includes content on  
288 coping with stress, mental preparation for combat, and suicide awareness and prevention.  
289 Mental health issues related to failure to adjust to the training environment most often occur  
290 within the first three weeks of training; beyond this point, most trainees will have appropriately  
291 adjusted to the stresses of BMT and separation from sources of support at home. The rigorous  
292 training regimen of BMT may also add to these issues by resulting in overtraining syndrome,  
293 which, among its constellation of symptoms, is mood disturbances. As such, BMT trainee  
294 suicidal ideation is unfortunately not uncommon,<sup>36</sup> and when a safety concern is identified,  
295 those trainees are transferred for inpatient evaluation and treatment. Upon hospital discharge,  
296 the trainee, having shown a significant inability to cope with stresses of the military, is  
297 separated from the USAF.<sup>37</sup>

298           Behavioral Analysis Service (BAS) at USAF BMT is made up of psychologists and social  
299 workers (active duty and civilian). The BAS mission is to “provide outpatient psychological  
300 evaluations, fitness for duty evaluations, and crisis intervention services for basic trainees” with  
301 an emphasis on fitness for duty evaluations.<sup>38</sup> One apparatus in place to assess trainee mental  
302 fitness for military service is the BEST Program and the Lackland Behavioral Questionnaire  
303 (LBQ), administered to all trainees at the start of BMT. Answers to these questions may trigger  
304 further evaluation in those at highest risk for mental health disturbances or issues with long-

305 term adaptation to the military. If a disqualifying current or past mental health diagnosis is  
306 identified, the trainee will be separated from the military. At the close of 2020, 60% of BMT  
307 separations during training were due to mental health reasons (2% of all BMT trainees are  
308 separated for this reason; internal data).

309 Although the primary BAS mission is to assess for mental fitness for duty, some brief,  
310 targeted interventions to address trainee issues with stress, sleep, and anger issues is offered.  
311 Other resources for a trainee struggling to adjust to military training can be found with the  
312 chaplaincy, embedded in each BMT squadron building and with BMT squadron leadership.

313 Expanding efforts to teach all trainees effective coping strategies (with opportunity to  
314 be practiced immediately in the stressful BMT environment) may be effective in enhancing  
315 trainee performance and preventing trainee attrition due to mental health reasons.

316 Additionally, embedding mental health professionals such as sport psychologists could optimize  
317 trainee performance and adaptations to military training resulting in improved graduation  
318 rates. If a trainee arrives, realizes the military is not for them and they wish to just go home,  
319 they are not afforded the option to do so. They have already made a commitment and the  
320 military has incurred a cost to recruit and bring them to JBSA-Lackland Air Force Base. Trainees  
321 in this scenario will feel a high degree of distress and enlistment remorse, which may result in  
322 suicidal ideation. Another consideration is “instrumental suicidality,” in which a trainee  
323 fabricates and reports suicidal ideation with the goal of being separated; processing for  
324 separation often eliminates these reported symptoms. Initiating an option for trainees to “ring  
325 the bell” and go home would likely decrease the rates of suicidal ideation, attempt,  
326 hospitalizations, and deaths.

327 **Conclusions**

328 Declining death rates at USAF BMT have continued from the first published review, and,  
329 as reported in this study, many steps have been put in place to minimize the risk of death.  
330 Three of the five of the deaths in this timeframe were exertion-related (two due to exertional  
331 sickling and one cardiac-related), which is consistent with previous investigations of military  
332 training.<sup>4,39</sup> Policies and practices have evolved to maximize the safety of trainees and minimize  
333 the risk of exertion-related sudden death during exercise (**see Figure 1**).

334 Regarding non-exertion-related deaths, the 13-year study period identified one death  
335 due to infection and one due to suicide. USAF BMT has notably reduced risks to trainees from  
336 infectious disease via continuous surveillance prevention and efforts. The mental health of  
337 trainees continues to be a priority for the Air Force at large, and BMT has continued efforts to  
338 provide the best screening, stress management, and intervention policies to accomplish the  
339 mission of the training environment as well as reduce suicidality in trainees as well as in the  
340 future active duty Airmen and veterans.

341 Overall, from 2008-2020, USAF BMT continued its tradition of minimizing the risks  
342 associated with military training and exercise while accomplishing its mission of transforming  
343 civilian volunteers to fit Airmen warriors. It is critical to utilize the best evidence-based training  
344 methods as informed by historical experiences and specialized medical support teams, as is  
345 currently the case with Trainee Health Surveillance, Trainee Health Clinic, Sport Medicine, and  
346 Behavioral Analysis Services. Success of this to date is best illustrated by noting that, at time of  
347 this writing, USAF is currently enjoying its longest stretch (five years) without a BMT trainee  
348 death.

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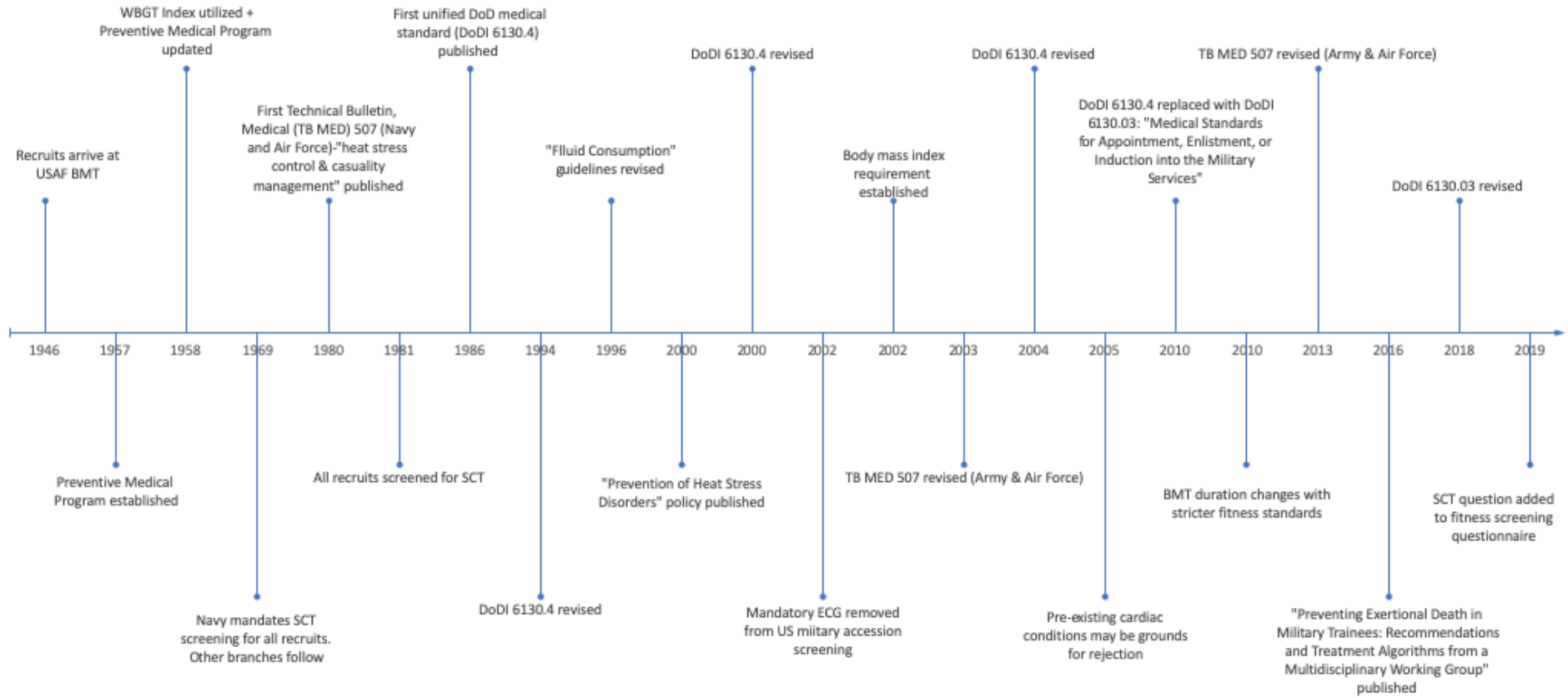
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Figure 1. Major Air Force Policy Changes for Exertional-related Sudden Death



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