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Sudden Infant Death and Social Justice: A Syndemics Approach

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11 **Abstract:**

12 Sudden Unexpected Infant Death (SUID) and Sudden Infant Death Syndrome (SIDS)

13 prevention has focused on modifying individual behavioral risk factors, especially

14 bedsharing. Yet, these deaths are most common among poor and marginalized people in

15 wealthy countries, including US Blacks, American Indians/Alaskan Natives, New

16 Zealand Māori, Australian Aborigines, indigenous Canadians, and low-income British.

17 The US now has the world's highest prevalence of SUID/SIDS, where even whites' SIDS

18 prevalence now approaches that of the Māori. Using public databases and the literature,

19 we examine SUID/SIDS prevalence and the following risk factors in selected world

20 populations: maternal smoking, preterm birth, alcohol use, poor prenatal care, sleep

21 position, bedsharing, and formula feeding. Our findings suggest that risk factors cluster in

22 high-prevalence populations, many are linked to poverty and discrimination, and have

23 independent effects on perinatal outcomes. Moreover, populations with the world's

24 lowest rates of SUID/SIDS have low income-inequality or high relative wealth, yet have

25 high to moderate rates of bedsharing. Employing syndemics theory, we suggest that

26 disproportionately high prevalence of SUID/SIDS is primarily the result of socially-

27 driven, co-occurring epidemics that may act synergistically to amplify risk. SUID must

28 be examined through the lens of structural inequity and the legacy of historical trauma.

29 Emphasis on bedsharing may divert attention from risk-reduction from structural

30 interventions, breastfeeding, prenatal care, and tobacco cessation. Medical organizations

31 play an important role in advocating for policies that address the root causes of infant

32 mortality via poverty and discrimination interventions, tobacco control, and culturally

33 appropriate support to families.

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37

38 **Introduction:** Approaches to prevention of Sudden Unexpected Infant Death (SUID) and
39 Sudden Infant Death Syndrome (SIDS) have historically emphasized individual behavior
40 change, most often focusing on bedsharing. Often overlooked in discussions about SUID
41 however, is that these deaths primarily occur among poor and marginalized people in
42 wealthy countries. Compared to rates of SUID/SIDS in their general populations,
43 markedly elevated rates have been found in US Blacks, American Indians and Alaskan
44 Natives, New Zealand Māori, Australian Aborigines, indigenous Canadians, and low
45 income British people. In this paper we draw on anthropological and social
46 epidemiological insights to argue that instead of this individualistic approach, we need to
47 consider the social origins, clustering or co-occurrence and interplay of known risk
48 factors (Ball et al., 2016; Singer, Bulled, Ostrach, & Mendenhall, 2017) in order to make
49 progress in reducing infant deaths in high-risk populations.

50

51 Definitions: SUID historically encompasses the following ICD-10 codes: SIDS (R95),
52 Ill-defined and Unspecified Causes of Mortality (R99), and Accidental Suffocation and
53 Strangulation in Bed (ASSB, W75). Overall, SIDS and SUID rates have fallen
54 dramatically between 2002 and 2012 and beyond in many countries, with the US being a
55 notable exception (B. J. Taylor et al., 2015).

56

57 Bedsharing and Co-sleeping: We define co-sleeping as whenever mother and infant are
58 sleeping within physical contact of one another. In this paper the word co-sleeping may
59 encompass bedsharing, but we will use bedsharing to specifically mean a mother sharing
60 an adult bed with her infant.

61

62 Physiologic basis for infant deaths associated with known risk factors. Below we briefly
63 review the physiologic mechanisms by which smoking, prone sleep, formula feeding,
64 preterm birth, and soft bedding such as sofas increase risk of death, independent of any
65 sociological context, eg poverty.

66

67 Smoking, both antenatal and post-natal, is thought to provide a physiologic basis for
68 death due to effect on serotonin (Duncan et al., 2009; Kinney, 2009), which affects
69 arousal, recovery from hypoxia and hypercapnia and thermoregulation. There is strong
70 evidence of a dose dependent effect of smoking and SIDS in combination with
71 bedsharing, particularly in maternal post-natal smoking (Zhang & Wang, 2013). Prenatal
72 smoking is associated with deficient hypoxia awakening responses (Lewis & Bosque,
73 1995) and attenuated recovery from hypoxemic challenges (Schneider, Mitchell, Singhal,
74 Kirk, & Hasan, 2008). Antenatal smoking also increases the risk of preterm birth (Ion &
75 Bernal, 2015), itself a risk for SUID.

76

77 Prone sleep position is associated with higher risk of death due to decreased arousability
78 and possibly due to heat stress, as the face is important for dissipation of heat in infants
79 (Kinney & Thach, 2009).

80

81 Preterm infants have a higher risk of SUID and SIDS inversely proportional to
82 gestational age (Ostfeld, Schwartz-Soicher, Reichman, Teitler, & Hegyi, 2017). In
83 addition to possible physiologic factors, preterm infants are more likely to bedshare and

84 to be placed prone to sleep (Colson et al., 2013; Hwang et al., 2015). Why preterm birth
85 increases risk of SUID is poorly understood, and it is possible that the same risk factors
86 that are responsible for the preterm birth may also be responsible for the increase risk of
87 SUID/SIDS, such as smoking. Hypotheses include hypoxia related to immature lung
88 function and lung and airway damage from mechanical or non-invasive ventilation
89 (Garcia, Koschnitzky, & Ramirez, 2013). Apnea of prematurity is not thought to be a
90 factor (Ostfeld et al., 2017).

91

92 Soft bedding and sofas provide a risk of death due to asphyxiation (Blair et al., 2009).
93 Alcohol or drug use may increase risk of asphyxiation by overlying as well as by falling
94 asleep in hazardous bedding circumstances such as sofas (Blair, Sidebotham, Pease, &
95 Fleming, 2014). Formula feeding is associated with an increased risk of SIDS
96 (Vennemann et al., 2009), likely due to decreased maternal and infant arousals with
97 decreased synchronization of mother-infant sleep (Mosko, Richard, & McKenna, 1997).
98 Breastfeeding beyond 2 months is associated with a lower risk of SIDS in a dose
99 dependent fashion (Thompson et al., 2017). Videographic data shows bedsharing
100 positions in formula feeding dyads which are more likely to be hazardous (Ball, 2006),
101 although other data shows no increased risk of death from bedsharing and formula
102 feeding if no other risks are present (Blair et al., 2014).

103

104 The complex contextual role of bedsharing – potential risks and protective effects

105 Proximate sleep and breastfeeding are part of the same evolutionary system (Ball,
106 2017b). Anthropologists Gettler and McKenna coined the term “breastsleeping” to reflect

107 the evolutionary and physiological integration of these activities (J. J. McKenna &
108 Gettler, 2015). Co-sleeping with breastfeeding is the physiological norm for humans and
109 other primates. In traditional societies all over the world, infants are carried by their
110 mothers 24 hours a day, nursing at will and sleeping with them at night (Barry & Paxson,
111 1971). Co-sleeping, including bedsharing, plays a key role in facilitating breastfeeding,
112 and therefore contributes to the protective effects of breastfeeding for SUID/SIDS.

113

114 Routine bedsharing has no risk of SIDS compared with unintentional bedsharing
115 (Vennemann et al., 2012). There is debate over whether bedsharing poses an independent
116 risk factor for SIDS. Blair et al. 2014 found that there is no additional risk in absence of
117 other risk factors, while the AAP has argued that bedsharing does pose an independent
118 SIDS risk (AAP 2016).

119

120 In some cases, bedsharing occurs in combination with other risk factors. For instance,
121 many mothers bedshare even if smoking and/or formula feeding (Lahr, Rosenberg, &
122 Lapidus, 2007). Although the independent role of bedsharing in these combinations is not
123 always clear, some of these behavioural combinations are associated with increased risk
124 (Lahr et al., 2007), (Blair et al., 2014).

125

126 In turn, separate or solitary sleep also carries risk of early weaning (Huang et al., 2013)
127 and stress to the infant. Infant cortisol levels remain high when infants are separated from
128 their mothers at night and maternal-infant cortisol asynchrony occurs (Middlemiss,
129 Granger, Goldberg, & Nathans, 2012).

130

131 SUIDS/SIDS prevention and bedsharing

132 Much attention has been given to SUID/SIDS and bedsharing, as infants have often been
133 found dead while sleeping next to an adult, either in a bed, or in a sofa or recliner. As a
134 result, numerous public health campaigns have strongly advised parents against
135 bedsharing. US public health campaigns have included scary images such as a tombstone
136 replacing the headboard of the adult bed. Such anti-bedsharing advice, however, may
137 have inadvertently contributed to adverse outcomes, including a 4 fold rise in sofa deaths
138 in the UK, as mothers fed infants on sofas and recliners at night in order to avoid
139 bedsharing, then fell asleep there (Blair, Sidebotham, Berry, Evans, & Fleming, 2006;
140 Kendall-Tackett, Cong, & Hale, 2010). Sofa-sharing poses far greater risk than sleeping
141 next to an infant in an adult bed (Moon & Task Force On Sudden Infant Death, 2016).
142 Because bedsharing facilitates breastfeeding and is associated with greater breastfeeding
143 duration (Ball et al., 2016; Huang et al., 2013; J. McKenna, Mosko, & Richard, 1997),
144 advice against bedsharing also has profound implications for the health of both women
145 and children (Victora et al., 2016). In response to a systematic assessment of the
146 evidence the UK has issued guidance that emphasizes the risks of smoking and sofa
147 sharing, prioritizes room sharing and encourages a contextual, informed choice approach
148 about bedsharing (Ball, 2017a; Bartick, Schwarz, et al., 2017). In 2016, the US's
149 American Academy of Pediatrics (AAP), also issued guidance acknowledging similar
150 risk factors, but maintained a more authoritative, less nuanced anti-bedsharing stance
151 (Ball, 2017a). For instance, it advised all parents to conduct night-time feedings in the
152 adult bed, but then to return the infant to a separate sleeping area (American Academy of

153 Pediatrics Task Force On Sudden Infant Death Syndrome, 2016). Despite a shift in
154 medical guidance towards more complex conversations about prevention between health
155 care providers and families, the framing of SUID/SIDS prevention continues to rely
156 primarily on individual behavior modification with little acknowledgment of the broader
157 social context in which SUID/SIDS risk is produced.

158

159 Conceptualizing social inequities and SUID/SIDS risk using syndemics theory

160

161 Poverty, racism and other forms of marginalization have been identified as key social
162 drivers of disease (Commission on Social Determinants of Health & World Health
163 Organization, 2008). Previous literature from the U.S. and around the world has
164 documented the role of poverty, racism and other forms of marginalization in poor
165 overall health as part of the emerging field of social determinants of health (Commission
166 on Social Determinants of Health & World Health Organization, 2008) In the US, a
167 review of the literature has found that “weathering,” the “chronic allostatic load
168 generated by the continuing adaptation to enduring structures of inequalities”
169 (Geronimus, 1992), generates --or at least contributes--to observed health disparities
170 among Blacks (Dresslers, Oths, & Gravlee, 2005). Increased cortisol levels due to acute
171 and chronic stress have been described as an effect of racism (Adam et al., 2015;
172 Richman & Jonassaint, 2008) and may reasonably be expected to increase with effects of
173 housing and food insecurity. Chronic stress among urban US Black, but not Hispanic,
174 pregnant women, is associated with flattening of the diurnal cortisol curve (Suglia et al.,
175 2010).

176

177 These socially produced stressors have significant implications for birth outcomes.
178 Chronic stress between pregnancies is associated with flattening of the normal diurnal
179 cortisol variation and is associated with a low birth weight child in the subsequent
180 pregnancy (Guardino et al., 2016). Maternal job strain is also associated with lower birth
181 weight infants, and these effects are roughly doubled in US Black women compared to
182 US white women (Oths, Dunn, & Palmer, 2001). Structural support can help mitigate
183 some of these stressors. For instance, access to antenatal care is associated with lower
184 infant mortality, and lower rates of preterm birth (C. R. Taylor, Alexander, & Hepworth,
185 2005). While housing insecurity may contribute to poor access to prenatal care, via
186 multiple stressors and transportation issues (Desmond, 2016), targeted increased access to
187 prenatal care to disadvantaged communities has been shown to reduce infant mortality
188 (Meghea, You, Raffo, Leach, & Roman, 2015).

189

190 Social inequities contribute to negative birth outcomes including lower birth weight and
191 preterm birth, which, in turn, influence the physiological risks of SUID/SIDS (Blair,
192 Platt, Smith, Fleming, & Group, 2006). Poverty is associated with previously
193 documented risk factors for SIDS in multiple settings, such as lower maternal educational
194 level (Sosnaud, 2017), unmarried status and younger age (Spencer & Logan, 2004).
195 Structural barriers and stressors are also reflected in behavioral risk factors for
196 SUID/SIDS are often associated with lower socioeconomic status: lower rates of
197 breastfeeding, maternal smoking and/or second hand smoke exposure (Zhang & Wang,
198 2013), parental drug/alcohol use (Blair et al., 2014), sofa sleeping (Moon & Task Force

199 On Sudden Infant Death, 2016), and non-supine positioning (Moon & Task Force On
200 Sudden Infant Death, 2016). Of these, smoking and/or alcohol combined with bedsharing
201 are especially hazardous, as is sofa-sharing.

202

203 Poverty is further implicated in poor access to prenatal care, which influences behavioral
204 risk factors linked to increased risk of SUID/SIDS, since it deprives providers of
205 opportunities to educate pregnant women in safe infant care practices, such as avoiding
206 soft sleeping surfaces, intervene in smoking cessation, and provide education and support
207 for breastfeeding. Moreover, poor breastfeeding support post-natally is also more
208 common in US hospitals serving African American communities (Lind, Perrine, Li,
209 Scanlon, & Grummer-Strawn, 2014), further contributing to SIDS risk. Thus, there is a
210 clustering of multiple risk factors in marginalized communities, many of which face
211 multiple forms of oppression and discrimination.

212

213 Teasing out the specific pathways in which co-occurring risks develop over time and lead
214 to their clustering is made particularly difficult because some risks are independently
215 associated with one another. Smoking is independently associated with lower
216 socioeconomic status in the US, Japan, and northern Europe (Fukuda, Nakamura, &
217 Takano, 2005; Kaneko et al., 2006; Loring, 2014), and is a cause of preterm birth
218 (Wallace, Aland, Blatt, Moore, & DeFranco, 2017). Smoking is associated with early
219 weaning (Liu, Rosenberg, & Sandoval, 2006). Alcohol use is associated with sofa-
220 sharing (Blair et al., 2009). The association of SUID with social disadvantage was
221 demonstrated in 51 of 52 case control and cohort studies between 1965 and 2002

222 (Spencer & Logan, 2004), most of which were done before the Back to Sleep campaigns.
223 This association was independent of maternal smoking in 9 out of 10 studies (Spencer &
224 Logan, 2004).

225

226 Anthropologists have used syndemic theory to describe similar patterns of disease
227 clustering, wherein social inequities result in multiple, co-occurring epidemics that may
228 interact to worsen some outcomes (Singer et al., 2017). These insights have generated a
229 large body of research in population health, especially in examining the relationship of
230 co-occurring psychosocial factors in the production of HIV-risk (Singer et al., 2017).
231 Despite significant attention to SUID/SIDS, to date the clustering and social origins of
232 co-occurring risk factors in marginalized populations has not been adequately theorized
233 or examined in relation to Sudden Infant Death. Our paper takes up this charge by
234 examining patterns of co-occurring risk factors and protective factors in low-prevalence
235 and high-prevalence settings for SUID/SIDS.

236 **Key Messages:**

237 -SUID and SIDS are primarily conditions of poor and marginalized people with legacies
238 of historical trauma living in wealthy countries.

239 -Syndemics theory highlights the social origins, clustering, and potential interaction of
240 risk factors like poverty, marginalization, preterm birth and smoking

241 -Emphasis on bedsharing is misplaced, as low-prevalence populations have high to
242 moderate rates of bedsharing.

243 -Comprehensive approaches to infant mortality are needed that address poverty, inequity,
244 and racial discrimination and include structural interventions for smoking cessation and
245 breastfeeding.

246 -Medical organizations should advocate for social equity as a means to health, but have
247 missed opportunities to do so.

248

249 **Methods:**

250 Using available public data bases and the literature, we compared SIDS and SUID
251 prevalence and their risk factors in Australia, Canada, Japan, New Zealand, the
252 Netherlands, Sweden, the United Kingdom, and the United States, as well as specific
253 subpopulations in Australia, Canada, New Zealand, and the US. Because rates of SIDS
254 and SUIDS are rapidly changing, mostly decreasing, and smoking rates are also rapidly
255 decreasing, preterm birth rates are decreasing, an effort was made to use those rates that
256 are temporally aligned. For the US, we used linked birth/death data but this was not
257 available or not labeled as such for New Zealand, Australia, Canada, or New Zealand.

258

259 In an effort to understand the high rates of SIDS and SUID in the US, we used the
260 CDC/WONDER interactive database, which allowed us to examine these rates by the
261 month prenatal care began in the affected infants, per racial and ethnic group for SIDS
262 and SUID. We examined the percentages of timely and late prenatal care in US
263 SUID/SIDS cases and in selected world populations. We calculated odds ratios (OR) with
264 95% confidence intervals (CI) on the odds of no and late prenatal care versus timely
265 prenatal care for each US racial or ethnic group on the odds of SIDS and SUID.

266

267 **Results:**

268 See Tables 1-5 and literature below. Citations from the tables will not be repeated in the
269 text.

270

271 Low-prevalence populations

272

273 The lowest SIDS prevalence is found in the Netherlands, followed by Japan and Sweden,
274 similar to previous data (Hauck & Tanabe, 2008). Asian Americans have the fourth
275 lowest prevalence of SIDS among the populations we studied (Tables 1 and 2). Of these
276 four populations with lowest prevalence of SIDS and SUID, three -- Sweden, the
277 Netherlands, and Japan -- enjoy universal health care and Sweden and the Netherlands
278 have especially low income inequality (Table 1). Like every industrialized nation but the
279 US, they also have paid maternity leave. Asian Americans have relatively greater wealth
280 compared to other US groups - over twice the median household income of US Blacks
281 and 1.3 times that of whites (Guzman, 2017).

282

283 Among Japanese, Swedes, and Asian Americans, both breastfeeding and bedsharing are
284 very common (Table 1). Sweden had the highest bedsharing rate in all of Western Europe
285 (Nelson et al., 2001) although it has decreased with recommendations against bedsharing
286 (Stromberg Celind, Wennergren, Mollborg, Goksor, & Alm, 2017). With universal
287 implementation of the Baby-Friendly Hospital Initiative (BFHI), Sweden also has
288 exceptionally high breastfeeding rates (Table 1). Sweden has half the pregnancy -

289 smoking rate of the US (Table 1). In Japan only 16.9% of preschool aged children have
290 their own bed (or futon) and only 1.4% have their own room (Mindell, Sadeh, Kwon, &
291 Goh, 2013), as family interdependence is strongly valued in contrast to Western values of
292 child independence (Jenni & O'Connor, 2005). Japan also has high breastfeeding rates.
293 Japan, however, has had historically very high male smoking rates (Table 1).

294

295 Compared with the above three low-prevalence populations, the Netherlands has lower
296 breastfeeding, moderate preterm birth rates but low overall infant mortality (Table 1),
297 suggesting overall excellent access to health care. Low pregnancy-smoking rates
298 compared to high population smoking rates may reflect that Dutch women have good
299 access to prenatal care (Table 1), as such access has been shown to help pregnant women
300 quit (Committee on Underserved Women & Committee on Obstetric Practice, 2017).

301

302 In the UK, which has a relatively low rate of SIDS, the proportion of SIDS deaths
303 occurring in term infants has significantly decreased from 1984-2003 (Table 1), whereas
304 the proportion in preterm infants has increased from 12% to 34% (Blair, Sidebotham, et
305 al., 2006). Furthermore, the proportion of UK SIDS deaths occurring in families living in
306 poverty has significantly increased from 47% to 74%, and the proportion of SIDS deaths
307 in infants of mothers who smoked during pregnancy has significantly increased from
308 57% to 87% (Blair, Sidebotham, et al., 2006). The UK has exceptionally low rates of
309 breastfeeding at 12 months compared to other industrialized nations (Victora et al.,
310 2016). Current government SUID rates (see Table 1) do not include ASSB.

311

312 Canada and Australia may be becoming countries with lowest rates of SIDS but we
313 would require SUID data to confirm that this is not merely diagnostic shift.

314

315 High-prevalence populations

316

317 In 2010, the United States led the world's high-income countries in the rate of post-
318 neonatal SUID, and the US and New Zealand were tied for the world's highest rates of
319 SIDS (B. J. Taylor et al., 2015), but by 2014 the US had surpassed even New Zealand for
320 both SIDS and SUID (Centers for Disease Control and Prevention & National Center for
321 Health Statistics, 2017 December; Ministry of Health, 2017b). In 2014, US AI/AN had
322 the world's highest SUID rate and SIDS rate, while New Zealand Māori were second in
323 SUID (Table 2). US AI/AN were highest in the world in SIDS, followed closely by US
324 Blacks, while Māori were a distant third, much of it ASSB (Table 2). In 2010-12, the
325 Māori rate of SIDS was 3.5 times that of the non-Māori, which is as low as that of
326 Sweden, one of the world's lowest (Ministry of Health, 2015). By 2014, this gap lowered
327 to 2.5, but the SUID rate in Māori was still 5.4 times that in non-Māori (Ministry of
328 Health, 2017b). The pregnancy-smoking rate among European New Zealanders was just
329 above that of Sweden. By contrast, in the US, even the SUID/SIDS rates among whites
330 are very high, with SIDS rates nearly approaching those of Māori.

331

332 New Zealand Māori

333 New Zealand's overall SIDS rates are now moderate. The Māori, however, continue to
334 experience disproportionately high rates.. Smoking rates among pregnant Māori are very

335 high, and hazardous alcohol use is also comparatively higher among Māori (Table 1).
336 New Zealand, like Sweden, has universal implementation of the BFHI. Overall
337 breastfeeding initiation rates are higher than those in Sweden, but Māori rates appear to
338 be significantly lower than that of non-Māori (Table 1). Bedsharing is comparatively much
339 more common among Māori (Table 1). Indeed, New Zealand researchers found the
340 combination of smoking and bedsharing increased the risk of SUID 32-fold compared to
341 infants with neither of these risks (Mitchell et al., 2017).

342

343 U.S.

344 In the US, unlike Australia, New Zealand, and Canada, rates of SIDS and SUID are high
345 even in the white population, but are markedly higher in the Black and American
346 Indian/Alaskan Native (AI/AN) populations (Tables 1-2). Tables 3-5 show poor prenatal
347 care is inversely associated with higher SIDS and SUID rates in a dose-response fashion
348 for almost every US ethnic group, but most pronounced in Whites, Asians, and Hispanics
349 (SUID only).

350

351 *US Blacks*

352 Average US Black family income is significantly lower than that of whites and US
353 Blacks continue to experience pervasive racism as discussed above (United States
354 Department of Labor Women's Bureau, 2015). While overall smoking rates are often
355 equal to or lower than those in the countries with lowest SIDS/SUID rates, Black children
356 have significantly greater exposure to second hand smoke: 67.9% compared to 37.2% for
357 white children (2011-12) (Homa et al., 2015). Black parents are more likely to place

358 infants to sleep prone, and more likely to sleep with their infants outside an adult bed,
359 such as a sofa (Unger et al., 2003). One Maryland study showed 9 of 10 co-sleeping
360 asphyxia deaths were in Black infants, most commonly on sofas, even though all homes
361 had cribs (Li, Zhang, Zielke, Ping, & Fowler, 2009). Finally, Blacks have the lowest
362 breastfeeding rates of any US ethnic group. Suboptimal breastfeeding rates among non-
363 Hispanic Blacks were determined to contribute to 1.95 the risk of SIDS in that population
364 compared to non-Hispanic whites (Bartick, Jegier, et al., 2017).

365

366 *U.S. American Indian/Alaskan Natives*

367 AI/AN median income is 69% that of the general population, and 27% live in poverty,
368 the highest of any ethnic group (US. Census Bureau, 2016), reflecting historical trauma
369 enacted by colonization, and continued racism and discrimination. AI/AN have high rates
370 of smoking and alcohol use. Bedsharing is comparatively more common than among
371 whites (Table 1). Breastfeeding rates are the second lowest of US ethnic groups after
372 Blacks. Recognizing this problem, in 2014 all Indian Health Service (IHS) Hospitals
373 became Baby-Friendly. However, IHS facilities only serve just over half of American
374 Indians (U.S. Department of Health and Human Services & Indian Health Service, 2018).

375

376 *First Nation and Inuit in Canada*

377 Although SIDS has declined in Canada overall, SIDS was the leading cause of infant
378 mortality in First Nation and Inuit populations in 2004-06 (Sheppard et al., 2017). These
379 populations also have similar experiences of historical trauma and poverty, and have very
380 high smoking rates, and comparatively lower breastfeeding rates and the Inuit have

381 extremely high preterm birth rates. The Canadian government does not appear to
382 routinely collect or publish infant health metrics by ethnicity. Bedsharing is very
383 common in the Inuit communities and among breastfeeding First Nation mothers (Table
384 1). The combination of marginalization, poverty, smoking in combination with
385 bedsharing with lower breastfeeding rates and poor access to prenatal care, especially in
386 remote areas, likely contribute to the high death rate.

387

388 Australian Aborigine and Torres Strait Islanders

389 Australian Aborigine and Torres Strait Islanders are by far the most socio-economically
390 disadvantaged sub-group in the Australian population with the worst overall health
391 outcomes (Australian Government & Department of the Prime Minister and Cabinet,
392 2014; Greenhalgh, Bayly, & Winstaley, 2017). They have high rates of smoking with
393 moderate bedsharing, and comparatively lower rates of breastfeeding. In one study, 81%
394 of Aboriginal infants were placed on their sides to sleep and only 8% were placed on
395 their backs (Eades & Read, 1999). The combination of poverty, high incidence of low
396 birth weight infants, smoking paired with bedsharing, and lower breastfeeding and racial
397 discrimination, likely explains high SUID/SIDS prevalence.

398

399 In the marginalized subpopulations in all four countries studied, the preterm birth rate or
400 low birth weight rate outpaces that of the ethnically dominant populations, although less
401 so in New Zealand. This is not mediated only by smoking as there are similar preterm
402 birth rates in the Netherlands and among Māori despite many times the pregnancy-
403 smoking rate among Māori, and very high rates among US Blacks with moderate

404 pregnancy-smoking rates. This suggests other complex factors related to access to care,
405 poverty, and racism may be playing a role, as supported by a previous analysis (Spencer
406 & Logan, 2004).

407

408 **Discussion:**

409

410 To our knowledge, this is the first work to employ syndemics theory to conceptualize and
411 systematically examine the distribution of SIDS and SUIDS and the clustering of its risk
412 factors in relation to underlying social inequities.

413

414 Our findings reflect the importance of social drivers of SUID/SIDS rates. Low-
415 prevalence populations generally have better healthcare and less inequality, which is also
416 linked to lower prevalence of poverty and fewer harmful health behaviors. In contrast,
417 several high-prevalence populations have experienced historical trauma and racism, and
418 continue to experience high rates of poverty, poorer access to high quality health care,
419 and comparatively higher harmful health behaviors. The legacy of historical trauma plays
420 an enduring role for generations of marginalized peoples. Australian Aborigines, Māori,
421 American Indians, First Nation and many Inuit and Alaskan Native people have all had
422 their lands confiscated and their traditional ways of life destroyed or upended by
423 European colonization, and their populations decimated by European diseases to which
424 they had no immunity. These communities also experience high rates of poverty and
425 poorer health due to these historical legacies. Structural racism persists long after the end
426 of slavery for African Americans, with generations left in poverty due to federal laws all

427 but prohibiting purchasing of real estate and accumulation of generational wealth, as but
428 one of many examples (Coates, 2014).

429

430 The specific pathways in the socially-driven accumulation of co-occurring factors, and
431 their interplay are very complex and require additional study. It is not clear whether these
432 factors produce poor outcomes via only co-occurrence or whether they interact in a
433 synergistic manner, meeting the current definition of a syndemic (Tomori et al., 2018).

434 Multiple statistical approaches are available for examining the accumulation and potential
435 interactions among co-occurring risk factors (Tomori et al., 2018; Tsai, 2018; Tsai,
436 Mendenhall, Trostle, & Kawachi, 2017). Future syndemics studies of SUID/SIDS should
437 combine these quantitative approaches with in-depth qualitative studies to gain better
438 understanding of the production of risk and to develop more effective prevention
439 interventions.

440

441 Our findings clearly indicate that factors that worsen income inequality, poverty, and
442 racial marginalization can be expected to increase infant mortality. The US has now
443 surpassed New Zealand as the world's leader in SIDS and SUID. The US has
444 experienced worsening income and educational inequality over the past several decades
445 (Greenstone, Looney, Patashnik, Yu, & The Hamilton Project, 2013), along with
446 concomitant rises in housing prices, which are now at a historic high percentage of
447 income (Kotkin, 2017). Additionally, inadequate government assistance to the poor
448 further contributes to poverty. For example, US food stamp benefits do not cover the cost
449 of meals in 99% of US counties (Dewey, 2018). In 2016, 41% of US children were either

450 poor or near-poor (Koball & Jiang, 2018). US infant mortality (5.9) exceeds the high-
451 income country average of 5.3 per 100,000. Our data suggest that lack of prenatal care
452 may play a large role in the high death rates even among US whites, although it is
453 difficult to know if this is a marker for poverty as well as playing a causal role.

454

455 UK statisticians attribute their decrease in smoking directly to the drop in SUID rates
456 (Patel, 2017), and this may be the case in other countries. However, smoking rates have
457 declined in the US while SUID rates have not, possibly because gains in smoking
458 cessation (and breastfeeding) are offset by factors related to rising poverty and persistent
459 racial discrimination.

460

461 Infant mortality is considered a metric for the health of a society. In the US, SIDS is the
462 third largest component of infant mortality after preterm birth and congenital anomalies
463 (Centers for Disease Control and Prevention, 2018). The high US SIDS/SUID rates serve
464 as a “canary in the coal mine” that US society has unacceptable social policies with
465 regard to poor families and pregnant women, and particularly women of color. The US
466 has neither paid maternity leave nor universal health care, and by far the highest metrics
467 for income inequality. These factors can be expected to affect all segments of the
468 population that are economically disadvantaged. In 2013, nearly 20% of US women had
469 no health insurance just before they became pregnant and about 14% had none post-
470 partum (Centers for Disease Control and Prevention, 2017).

471

472 Risk factors may compound one another or work to offset one another. The combination
473 of bedsharing, high breastfeeding rates, low pregnancy smoking rates, and excellent
474 access to care may result in very low infant death rates even with modest societal tobacco
475 use, as in Sweden and Japan. By the same token, higher pregnancy-smoking and
476 bedsharing rates, even with good access to care, may result in increased risk of
477 SUID/SIDS (Māori). While bedsharing can be part of the cluster that produces higher
478 SUID/SIDS prevalence, it can also be an important part of a set of protective behaviors,
479 like breastfeeding.

480

481 The risk factors for the two biggest preventable causes of infant mortality, preterm birth
482 and SIDS, largely overlap. These conditions should not be siloed, and undue focus on
483 bedsharing at the expense of emphasis on tobacco exposure, prenatal care, and
484 amelioration of poverty and racial discrimination will fail to result in sufficient reductions
485 in infant mortality. Adverse health outcomes are related to income inequality, structural
486 racism for those countries with populations of marginalized groups, social safety nets
487 play an important role for vulnerable populations in addressing children's health. Parallel
488 efforts to reduce preterm birth, including reducing antenatal smoking, will also help
489 reduce infant death from co-sleeping and other causes.

490

491 Finally, given the role of numerous societal factors in the multiple interplaying risk
492 factors for infant death, recommendations to individual parents and health care providers
493 must be accompanied by recommendations for social policy makers in order to effect any
494 meaningful change the rate of infant death. Individuals should not be expected to reverse

495 burdens placed on them by history and an inequitable social structure. Medical
496 organizations' recommendations depend on individuals to take individual action, but as
497 the problem of SUID/SIDS is much greater than the actions of any of individual, some
498 solutions must ultimately originate from the policy level.

499

500 New Zealand has been successful in markedly bringing down both SIDS and SUID rates
501 since 2009 (Ministry of Health, 2017a) and they should be looked at as a leader in this
502 field, although marked disparities continue. Some success is undoubtedly attributable to
503 the Wahakura and Pepi-pod on-the-bed sleeping devices (Abel & Tipene-Leach, 2013).
504 The Wahakura was inspired by a revival of traditional Māori sleeping devices and was
505 developed by and with the Māori community (Baddock et al., 2017; Bartholomew, 2017).
506 Nearly all hospitals are now Baby-Friendly. The government collects and makes public
507 all data on Māori and other minority groups for nearly every health metric examined
508 here. New Zealand has also implemented a large stepwise tobacco tax as of 2017 (Radio
509 New Zealand, 2017). The similar rates of preterm birth among the Netherlands and Māori
510 may also represent success of the New Zealand maternity care system, where access to
511 prenatal care is nearly equal between Māori and non-Māori, (Ministry of Health, 2012),
512 illustrating success in preventing preterm births despite having twice the pregnancy
513 smoking rate.

514

515 Limitations

516 This study is limited by the instability of the rates SIDS, SUID, and smoking in most of
517 the populations studied. There may be diagnostic shift away from SIDS, as well as

518 lowering of SUID due to the secular trend in lower smoking rates. In addition, different
519 countries may code infant deaths differently. Female alcohol related deaths may not
520 adequately reflect current levels of hazardous drinking among new mothers, nor among
521 co-sleeping fathers. There is no universal consistent definition of nearly every term in
522 Table 1, and neither the Australian government nor the UK (England/Wales) government
523 definitions of SUID include ASSB (W75). Even SIDS has no consistent definition across
524 localities. We did not examine every risk factor for SUID/SIDS, such as pacifiers or
525 swaddling. Within the bedsharing and sleep position statistics, variability exists that may
526 further influence outcomes, such as sofa sharing, degree of usual bedsharing, and side
527 versus prone sleep.

528

529 Recommendations

530

531 Structural interventions to reduce risk and enhance protective behaviors

532 Smoking: Although smoking rates are declining and are lower in the US than in some
533 other countries, incremental change will help make bedsharing safer and reduce infant
534 death. Tobacco-mediated infant death is thus best prevented by proven population-based
535 tobacco control interventions in addition to individual smoking cessation advice and
536 supportive interventions. Tobacco prices are most sensitive among younger and lower
537 income people. Data from over 53 million births across 24 European countries showed
538 that a price increase of \$1.18 per pack of cigarettes was associated with a decline of 0.23
539 deaths per 1000 live births in the same year and 0.16 deaths per 1000 live births the
540 following year (Filippidis, Lavery, Hone, Been, & Millett, 2017) Relief of stressful

541 living conditions, directly linked to poverty and racism, would also be important to
542 recognize. Therefore supportive, rather than stigmatizing, interventions are needed.

543

544 Based on “strong evidence,” the Community Preventive Services Task Force of the
545 Centers for Disease Control and Prevention recommends increases in the unit price for
546 tobacco as a means to decrease tobacco use (Community Preventive Services Task Force,
547 2017). Interestingly, price increases are not even mentioned as a possible strategy by
548 either the AAP’s tobacco prevention policy statement (Farber, Groner, Walley, Nelson, &
549 Section On Tobacco, 2015) or by the American Cancer Society’s Tobacco Atlas (Eriksen,
550 Mackay, Schluger, Gomeshtapeh, & Drope, 2015).

551

552 Sidecars and on-the-bed sleeping devices such as Wahakura or Pepi-pods may minimize
553 smokers’ exposure to their infants in bed or prevent asphyxiation and SIDS. Their use
554 should be further explored for acceptance, safety, and efficacy.

555

556 Breastfeeding: Governments and non-governmental organizations can help improve
557 breastfeeding rates through investments and policies. Both Sweden and New Zealand
558 have mandated and supported all hospitals to become Baby-Friendly and in the US
559 publicly funded and privately funded efforts are targeting hospitals in parts of the country
560 with the greatest breastfeeding disparities to become Baby-Friendly. As a result,
561 breastfeeding rates have been proportionally increasing among African American and
562 American Indian populations. Paid leave, peer counseling, and access to culturally-
563 appropriate breastfeeding support are important. Equally important are medical and

564 governmental policies that do not undermine breastfeeding, such as policies that
565 inappropriately demonize bedsharing, or allow aggressive marketing of infant formula.
566

567 Building a Social Safety Net and Addressing Racism. The most challenging social
568 causes of risks to modify are poverty and racism. Infants, young children, and their
569 families are among society’s most vulnerable members, and infant health begins during
570 pregnancy. Housing and food insecurity, poor access to prenatal care, smoking, and poor
571 breastfeeding support, all contribute to adverse health outcomes seen. At a minimum,
572 pregnant women and families need safe, stable housing and food security in order to
573 maximize the chances for health of their children. They also need universal access to
574 healthcare and paid parental leave. Access to care may help educate and ameliorate high
575 risk sleeping situations, as well as decrease the risk of poor birth outcomes.

576 Finally, ongoing efforts must bring the legacies of colonialism to light, as in the case of
577 the Truth and Reconciliation Commission in Canada (Truth and Reconciliation
578 Commission of Canada, 2015), and continue to systematically address racism and social
579 inequities. While raising tobacco prices and breastfeeding may augment these ongoing
580 trends in the US, the US may not see further reduction in reducing infant mortality until
581 there are substantive changes that affect poverty, inequity, and racial discrimination.
582 Indeed, without such changes, infant mortality in the US can reasonably be expected to
583 rise.

584

585 **Conclusions**—A syndemics analysis of SUID shows that it is primarily a condition of
586 poor and marginalized populations who continue to cope with the legacies of historical

587 trauma. SUID has many of the same risk factors as preterm birth. Smoking, poverty,
588 alcohol/drug use, low breastfeeding rates, and unsafe sleep environments are common
589 mediators of SUID and SIDS. A coordinated emphasis on reducing infant mortality by
590 reducing tobacco use and preterm birth, addressing poverty and disparities, and
591 promoting breastfeeding, would be much more effective than addressing SUID and SIDS
592 in isolation. Misplaced emphasis on individual behavior practices like bedsharing, rather
593 than on these combined factors will not be expected to lower infant mortality. The US
594 stands out with its stagnant and high mortality rates and its increasing income inequality,
595 high levels of child poverty, and the dismantling of the social safety net. These factors
596 can reasonably be expected to result in increasing US SUID/SIDS and overall infant
597 mortality rates in the future. Medical organizations play an important role in advocating
598 for broad social policy change. The alarmingly high rate of preterm birth and SUID
599 throughout most of the US population should serve as a call to action to reduce poverty,
600 improve the social safety net, and ensure health care for all.

601

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Table 1. Comparison of Selected World Populations by SIDS rates, SUID rates, and Selected Risk Factors

	SIDS, ASSB per 1000 live births (2002-10)	SUID per 1000 live births (2002-10)- see notes	SIDS per 1000 live births (most recent gov't figures)	SUID per 1000 live births (most recent gov't figures) -see notes	Pre-term Birth (%) (2010)	Infant mortality rate per 1000 live births (2013)	Any breast-feeding at 6 months (%)	Pregnancy smoking rate (%) (2010), Female smoking rate (%) (2015)	Gini Coefficient and Quintile Ratios per nation, (2010-15)	Bedsharing as a cultural norm, at least sometimes (%)	Supine sleep as a cultural norm (%)	Alcoholic liver cirrhosis mortality in females per 100,000 (see notes)	Comments
Australia	0.31, 0.32	0.50	0.32 (2010) 0.07 (2015)	n/a	7.6	3.4	56 (2011) 60.1 (2010)	11.7, 13.1 (Male 16.7)	34.9, 6.0	30 (Brisbane)	No recent data available	2.0 (2010)	
Australian Aborigine/ Torres Strait Islander (2.8% population)	n/a	n/a	0.6 (2008-12)	1.2 (2008-12) – See notes	12.6 (Low birth-weight, 2011)	6.2 (2008-12)	45.4 (2010)	49.3, 42 (2012-13)		40 (South Australia)	8 (Perth)	20.3(2008-12, both sexes, “alcohol related disease”)	
Australian non-Aboriginal	n/a	n/a	0.2 (2008-12)	0.4 (2008-12) See notes	6.0 (Low birth-weight, 2011)	3.7 (2008-12)	60.3 (2010)	12.1, Extrapolate to 17.3 (2012-12) (percentage of non-indigenous 18-24 year olds)		30 (Brisbane)	No recent data available	3.9 (2008-12, both sexes, “alcohol related disease”)	
Canada	0.33,	0.45	0.24	n/a	7.8	4.6	30	10.5-23,	33.7, 5.8	23	77	3.3 (2012)	

	0.03		(2010) 0.06 (2013)				(2011-12)	12.2 (Male 17.7) (18.3 in (2006-10)		(Manitoba)			
Indigenous Canadians (4.9% population: 58% First Nation, 35% Métis, 3.9% Inuit)	1.2 (1991-2000 First Nation, 6.8 (1991-2000) Inuit in Quebec	5.7-6.1 (1999-2011) Inuit in Nunavut	2.0 (2004-06)	Does not collect	8.7 (2004-06) First Nation 8.2, Métis 6.3, Inuit 11.4	9.6 (2004-06) First Nation 7.5, Métis 7.1, Inuit 9.9	Initiation (2007-10)- 60.2-78.2	Female smoking rates: 39.4-59.3 (Northern Territories 2006 and 2010); 34.2 (Métis), 39.1 (First Nation), 48.9 (Inuit) (2006-10). Inuit women 73.6 (2012)		58-63 (Inuit) 100 among breast-feeding First Nation mothers (British Columbia, Manitoba, Ontario)	38-46 (Inuit Nunavut)	n/a	In First Nations families, family beds are common. Sofa-sharing with fathers described. Family beds may be piled high with blankets to stave off cold.
Canadian non-indigenous	n/a	n/a	0.3 (2004-06)	Does not collect	6.7 (2004-06)	4.4 (2004-06)	Initiation 87.8 2007-10)	non-indigenous pregnancy not known, 17.6 (2006-10)		23 (Manitoba)	77	n/a	
Japan	0.20, 0.06	0.60	0.1 (2015)	n/a	5.9	2.1	63 (2009)	5.1, 10.6 (Male 33.7)	32.1, 5.4	37 (Tokyo/Yokohama). Likely underestimate: as only 16.9% preschool children have their own	97	1.8 (2012)	Note high male smoking rate; families sleeping together and sibling bedsharing is common.

										bed.			Sleeping on futons is common.
Netherlands	0.10, 0.02	0.19	0.09 (2013) 0.04 (2015)	n/a	8.0	3.3	32 (2006-08)	6.2, 23.9 (Male 26.2)	28.0, 4.5	40.4	84.6	1.7 (2012)	
New Zealand	0.62, 0.34	1.01 (1.02 per NZ gov't)	0.30 (2012-14)	0.75 (2014)	7.6 (7.4 per NZ gov't)	5.2 5.7 (2014)	60 (2006) 26% exclusive/full (2014)	18.4, no female data	33.5 (2010-14, NZ gov't Gini)	19 (Dunedin)	72 (Auckland)	1.4 (2012), Female hazardous drinking 11.7%/Male 27.2%	
NZ Māori (14.9% of population)	1.64	2.30 (SUID per NZ gov't)	0.45 (2012-14)	1.82 (2014)	8.1	7.2 (2014)	16% exclusive/full (2014-15-)	31.6 (2009-10), no female data		67.2 (includes Wahakura and Pepipod)	No data	Hazardous drinking Female 18.8%/Male 34.3%	
NZ non-Māori	0.39	0.51 (SUID per NZ gov't)	0.24 (2012-14)	0.34 (2014)	7.2	5.1 (2014)	30% exclusive/full (2014-15)	6.8 (2009-10) European, no female data		19 (Dunedin)	No data	European Female 11.6%/Male 27.5%	
Sweden	0.17 (2002-11), ASSB rate too low to be reliable	0.34 (2002-11)	0.18 (2013) 0.22 (2015)	n/a	5.9	2.4	52 (2010)	4.9, 20.8 (Male 20.4)	27.3, 4.2	65 (Stockholm) 44.2; 87.1 if breastfeeding (2012-14)	84.4	2.0 (2012)	
United Kingdom	0.28 (Eng.)	0.45 (Eng.)	0.18 (2014)	0.31 (2014),	7.8	3.9	34 (2005-	12, 18.4 (Male 19.9)	32.6, 5.3	32 (Scotland) 56 among	94.3 (white Bradford)	5.5 (2012)	

	and Wales), 0.02	and Wales)	0.17 (2015) (Eng. and Wales)	0.27 (2015) (Eng. and Wales) —See notes			10)			breast- feeding 84.4 (Bradford)	81.6 (Pakistani immigrants Bradford)		
United States	0.54 (0.53 CDC), 0.14	0.95 (0.95 CDC)	0.39 (2014)	0.87 (2014)	12.0	5.8 (2014)	49 (2011)	10.0, 13.6 (Male 18.1)	41.1, 9.1	61.4 (24.4 often/always)	78.4	4.4 (WHO 2012), (3.9 CDC 2010-14)	.
US Blacks (13.3% of population)	1.01, 0.32	1.88	0.67 (2014)	1.85 (2014)	17.1	10.9 (2014)	35 (2011)	8.5, 13.3		76.4 (35.3 often/always)	62.4	2.6 (2010- 14)	Data suggests more common use of sofa- sharing compared to whites. High rates of second- hand smoke.
US AI/AN (1.3% of population)	1.17, 0.33	2.15	0.88 (2014)	1.92 (2014)	13.6	7.7 (2014)	37 (2011)	17.1, 24.0		83.9 (56.1 often/always)	80.2	26.0 (2010- 14)	
US whites (76.9% of population)	0.53, 0.14	0.90	0.39 (2014)	0.82 (2014)	10.8	4.9 (2014)	52 (2011)	13.9, 16.0		52.7 (17.5 often/always)	83.9	3.4 (2010- 14)	
US Hispanic (17.8% of population)	0.28, 0.06	0.53	0.24 (2014)	0.54 (2014)	11.8	5.0 (2014)	48 (2011)	2.0, 7.1		66.7 (28.7 often/always)	73.5	2.7 (2010- 14)	
US Asian/Pacific Islander (Asian 5.7%; PI 0.2% of	0.23, 0.05	0.41	0.15 (2014)	0.29 (2014)	10.7	3.7 (2014)	71 (2011, Asian only)	1.3, 2.6 (Asian only)		76.8 (37.0 often/always)	79.2	0.5 (2010- 14)	

General notes:

- AI/AN: American Indian/Alaskan Native; ASSB: Accidental Suffocation and Strangulation in Bed; CDC: Centers for Disease Control and Prevention; ICD: 10th Revision of the International Statistical Classification of Diseases; n/a: not available; NZ: New Zealand; PI: Pacific Islander; SIDS: sudden infant death syndrome; SUID: sudden unexpected infant death; WHO: World Health Organization.
- 2002-2010 data come from (Taylor et al., 2015) for Australia, Canada, Japan, Netherlands, UK (England and Wales), US (overall). Sweden's data data is 2002-11 comes from (Möllborg, Wennergren, Almqvist, & Alm, 2015). New Zealand data is calculated from (Ministry of Health, 2017a) using the New Zealand government's definition of SUID, which is not spelled out. US subpopulation data was calculated using the exact SUID ICD-10 definitions used by Taylor et al using the CDC WONDER database using linked birth/death data (Centers for Disease Control and Prevention & National Center for Health Statistics, 2017 December).
- Recent government European SIDS rates come from (Eurostat, 2018).
- Most infant mortality data come from (World Health Organization, 2015), except for subpopulations in US, New Zealand, Canada.
- Preterm birth by country (2010) come from a joint report from the WHO (March of Dimes, PMNCH, Save the Children, & World Health Organization, 2012), except for subpopulations
- Breastfeeding rates come from the appendix to (Victora et al., 2016), unless otherwise specified for subpopulations.
- Most tobacco data come from (World Health Organization, 2016), except for subpopulations.

-Gini Coefficient and Quintile Ratios (indexes of income inequality) come from the United Nations Human Development Report 2016 (Jahan, Jespersen, & Human Development Report 2016 Team, 2016)

-Bedsharing at 3 months (Nelson et al., 2001) unless otherwise specified.

-Supine sleep data is reported by individual populations (see countries below).

-Mortality of Alcohol Use Disorders adult females, comes from (World Health Organization, 2014) unless otherwise stated. It is calculated by taking using listed rates in their tables for age standardized death rates for liver cirrhosis and multiplying it by the alcohol attributable fraction of liver cirrhosis. See separate note for the United States.

Australia notes

-Australian Aboriginal population data come from 2016 census.

-Australian SUID in Aborigines and non-Aborigines was defined as SIDS plus “signs, symptoms and ill-defined conditions” in the Australian Government Report for 2012-13, which would imply R99, but not W75.

-Preterm data was not available for Australian Aboriginal infants but low birthweight data came from Australian Government Report, for 2012-13(Australian Government & Department of the Prime Minister and Cabinet, 2014). This report also supplied alcohol mortality and infant mortality in Australian subpopulations (Australian Government & Department of the Prime Minister and Cabinet, 2014).

-Markedly different rates for Australian breastfeeding at 6 months between 2010 and 2011. (Australian Institute of Health and Welfare, 2018)

-Pregnancy smoking data comes from (Z. Li, Zeki, Hilder, & Sullivan, 2013).

-Aborigine bedsharing data comes from (Cunningham, Vally, & Bugeja, 2018).

-Australian Aborigine sleep position data from (Eades & Read, 1999).

Canada notes

-Subpopulation percentages come from the 2016 Canadian census.

-2004-06 SIDS rates for indigenous and non-indigenous Canadians come from (Sheppard et al., 2017).

-Preterm birth rates for indigenous and non-indigenous Canadians come from (Sheppard et al., 2017).

-2004-06 infant mortality rates for indigenous and non-indigenous Canadians come from (Sheppard et al., 2017).

-Breastfeeding rates in indigenous Canadian and non-indigenous include Métis (McIsaac, Moineddin, & Matheson, 2015). Data is extremely sparse and does not appear to be collected routinely for these populations.

-Pregnancy smoking data comes from (Al-Sahab, Saqib, Hauser, & Tamim, 2010) for 2006 and (Cui, Shooshtari, Forget, Clara, & Cheung, 2014) for 2010.

-Female Smoking data for indigenous Canadians come from (Physicians for a Smoke-Free Canada, 2013) and from (Bougie & Kohen, 2018).

-Sleep position in Inuit and Canada and bedsharing data in Inuit and Canada from (Collins et al., 2012).

-Bedsharing data from First Nation mothers comes from (Eni, Phillips-Beck, & Mehta, 2014).

Japan notes

- Japanese 2015 SIDS rates come from (Ministry of Health Labour and Welfare, 2016).
- Japanese pregnancy smoking data comes from (Yasuda et al., 2013).
- Japanese supine sleep and smoking rates from 2010-11 come from (Hirabayashi et al., 2016).
- Data on Japanese preschool children having their own bed comes from (Mindell, Sadeh, Kwon, & Goh, 2013).

Netherlands notes

- Netherlands bedsharing and sleep position data come from (van Sleuwen, L'Hoir, Engelberts, Westers, & Schulpen, 2003).
- Smoking in pregnancy data comes from (Zeitlin, Mohangoo, & Delnord, 2012).

New Zealand (NZ) notes

- New Zealand subpopulation data comes from 2017 New Zealand census.
- New Zealand SIDS and SUID data for 2002-2010 calculated from (Ministry of Health, 2017a). SUID was defined by NZ government.
- New Zealand SUID 2014 data calculated by adding R95, R99, and W75 from (Ministry of Health, 2017b).
- New Zealand subpopulation preterm birth data taken from (Ministry of Health, 2012).
- 2014 infant mortality rates from NZ and subpopulations come from New Zealand Government report (Ministry of Health, 2017b).
- New Zealand breastfeeding data for 2014 come from 2010-2015 data from (Royal New Zealand Plunket Society, 2017).

- Antenatal smoking rates from New Zealand and subpopulations (2010) come from (Humphrey, Rossen, Walker, & Bullen, 2016).
- UN did not publish Gini coefficient or Quintile Ratio for New Zealand. New Zealand Gini coefficient came from (Ministry of Social Development, 2016).
- Alcohol use in New Zealand subpopulations comes from (Ministry of Health, 2004).
- Sleep position data comes from (Hutchison, Stewart, & Mitchell, 2006).
- Māori bedsharing data from (Jones, Cornsweet Barber, Waimarie Nikora, & Middlemiss, 2017).

Sweden notes

- Swedish data for 2002-11 comes from (Möllborg et al., 2015), as Sweden was not included in the Taylor study. It is unclear if every case of SUID was included. Total live births in Sweden 2002-11 numbered 762,626 from (Statistiska Centralbyrån- Statistics Sweden, 2018).
- Smoking in pregnancy data comes from (Zeitlin et al., 2012).
- Swedish 2010-14 bedsharing and sleep position data is from (Stromberg Celind, Wennergren, Mollborg, Goksor, & Alm, 2017).

United Kingdom (UK) notes

- UK (England and Wales) SIDS and SUID rates from 2014 and 2015 come from (Patel, 2017). The description notes they use linked birth-death data for R95 and R99 but do not mention W75. Thus, these may be gross underestimates for SUID.
- Smoking in pregnancy data comes from (Zeitlin et al., 2012).

-Bedsharing data among breastfeeding mothers (at least “intermittently” or “often”) comes from (Ball et al., 2016) but there was insufficient data for 22% of respondents.

-Bedsharing and supine sleep data among the Bradford sample comes from (Ball et al., 2012).

United States (US) notes

Note: White, Black, American Indian/Alaskan Native (AI/AN), and Asian/Pacific Islander (PI) are all “non-Hispanic.”

-US subpopulation census estimates come from 2016 census estimates and include both non-Hispanic and Hispanic (United States Census Bureau, 2018).

-SIDS rates for 2002-2010 for US subpopulations calculated from CDC WONDER (Centers for Disease Control and Prevention & National Center for Health Statistics, 2017 December). SIDS and SUID subpopulation data also come from CDC WONDER. SUID for 2014 defined as R95, R99, and W75.

-Preterm birth rates in US and subpopulations come from (US Department of Health and Human Services, Health Resources and Services Administration, & Maternal and Child Health Bureau, 2012).

-SUID rates for US subpopulations 2002-2010 were calculated from CDC WONDER using the same ICD-10 codes from Taylor (2015): R95, R96, R98, R99, W75, W78, W79 (Centers for Disease Control and Prevention & National Center for Health Statistics, 2017 December). Note, this gave a total SUID rate of 0.96.

-US subpopulation infant mortality data (2014) come from (National Center for Health Statistics (US), 2017).

-Breastfeeding data from US subpopulations comes (Centers for Disease Control and Prevention, 2017a).

-Smoking in pregnancy data comes from (Child Trends Data Bank, 2016).

-Female and male smoking rates for US and subpopulations for 2015 come from (Jamal et al., 2016).

- Bedsharing and supine sleep data come from US Pregnancy Risk Assessment Monitoring System data in 2015 (Bombard et al., 2018).
- Sofa-sharing data in US Blacks comes from mortality data in (L. Li, Zhang, Zielke, Ping, & Fowler, 2009; Unger et al., 2003).
- Second hand smoke data in US Blacks and smoking rates in US subpopulations in US Blacks comes from CDC WONDER (Centers for Disease Control and Prevention, 2017b).
- CDC WONDER is the source for 2010-14, among females, all ages, per 100,000 persons(Centers for Disease Control and Prevention & National Center for Health Statistics, 2017 December). Rates reflect all “Alcoholic Liver Disease” (ICD-10 codes K70.0, K70.1, K70.3, K70.4, K70.9) to better approximate the values estimated by the WHO. When just the ICD-10 code for alcoholic cirrhosis is used, K70.3, the overall US rate was 2.6, far lower than the WHO estimate. Using this code alone, rates for US Blacks are: 1.8, for AI/AN 14.6, for whites 2.9, for Hispanics 2.0, and for Asian/Pacific Islanders 0.3.

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Table 2. Rates of SIDS, ASSB, SUID, 2014, in selected US and New Zealand Populations, per 1000 live births

	SIDS	ASSB	SUID
US American Indian/Alaskan Native	0.84	Not reliable	1.92
US Blacks	0.74	0.52	1.70
New Zealand Māori	Not reliable	1.40	1.82
United States	0.39	0.21	0.87
US whites	0.38	0.20	0.82
New Zealand	0.24	0.52	0.75
US Hispanic	0.24	0.11	0.54
New Zealand non-Māori	Not reliable	Not reliable	0.34
US Asian	0.15	Not reliable	0.29

Note: SUID as defined as R-95 R-99, and W-75. (American Indian/Alaskan Native, Black, and white refer to non-Hispanics only). US data are linked birth/death data. US Data come from (Centers for Disease Control and Prevention & National Center for Health Statistics, 2017 December). New Zealand data is not stated as being linked and comes from (Ministry of Health, 2017). Numbers where denominator is less than 20 are considered “not reliable.” ASSB: Accidental Suffocation and Strangulation in Bed; SIDS: sudden infant death syndrome; SUID: sudden unexpected infant death.

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Table 3. US SIDS and SUID rates per 1000 live births, by subpopulation, by month prenatal care started, 2010-2015

	SIDS, No prenatal care	SIDS, Third trimester	SIDS, Second trimester	SIDS, First trimester	SIDS, overall	SUID, No prenatal care	SUID, Third trimester	SUID, Second trimester	SUID, First trimester	SUID, overall
US overall	1.03	0.74	0.62	0.32	0.43	2.50	1.53	1.28	0.67	0.88
Black	1.37	0.98	0.96	0.62	0.80	3.72	2.30	2.13	1.40	1.58
AI/AN	Unreliable	Unreliable	1.29	0.85	1.00	Unreliable	2.33	2.48	1.88	1.98
White	1.27	0.82	0.68	0.33	0.43	2.65	1.71	1.37	0.66	0.72
Hispanic	0.46	0.43	0.34	0.19	0.25	1.43	0.81	0.71	0.40	0.72
Asian/PI	Unreliable	0.42	0.24	0.13	0.17	Unreliable	0.65	0.45	0.26	0.29

Note. Figures in which the numerator is under 20 are deemed as “unreliable.”

Overall figures include infants for whom prenatal care was not listed on certificate or those whose prenatal care status was listed as “excluded.” Black, AI/AN, White, and Asian/PI are all non-Hispanic. AI/AN: American Indian/Alaskan

Native; PI: Pacific Islander; SIDS: sudden infant death syndrome; SUID: sudden unexpected infant death. Source: CDC WONDER linked birth-death records (Centers for Disease Control and Prevention & National Center for Health Statistics, 2017 December), using R95 (SIDS) and R95, R98, R99, and W75 (SUID).

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Online Database. Retrieved from <http://wonder.cdc.gov/ucd-icd10.html>

Table 4. Percentage of SIDS and SUID cases that received timely (ie, first trimester) prenatal care or late (third trimester) or no prenatal care, by racial/ethnic group, and overall prevalence of late or no prenatal care

	SIDS cases with timely prenatal, 2010-15 (%)	SIDS cases with timely prenatal care, 2010-15 (%)	Timely prenatal care (%)	SIDS cases with late or no prenatal care (%) 2010-15	SUID cases with late or no prenatal care (%), 2010-15	Prevalence of late or no prenatal care xs(%)
US overall	45.1	46.0	74.1 (2012)	9.1	9.9	6.0 (2014)
US Black	38.3	39.6	63.6 (2012)	10.4	11.8	4.3 (2014)
US AI/AN	37.9	30.3	59.4 (2012)	12.1	12.0	10.8 (2014)
US white	48.7	49.8	79.0 (2012)	7.4	7.6	5.2 (2014)
US Hispanic	53.9	32.8	69.0 (2012)	14.3	8.6	7.5 (2014)
US Asian/PI	50.2	50.1	78.0 (2012, Asian only)	10.6	9.4	5.7 (2014)
Australia			65 (2015)			
Australia indigenous			57 (2015)			
Australia non-indigenous			63 (2015)			
Japan						0.3 (no care 2009)
Netherlands			87.3 (2010)			6.2 (2010)
UK: England			77.6 (2010)			9.6 (2010)
UK: Scotland			87.3 (2010)			2.3 (2010)

Note. Black, AI/AN, White, and Asian/PI are all non-Hispanic. AI/AN: American Indian/Alaskan Native; PI: Pacific Islander; SIDS: sudden infant death syndrome; SUID: sudden unexpected infant death. Sources: CDC WONDER for SIDS and SUID cases 2010-2014 (Centers for Disease Control and Prevention & National Center for Health Statistics, 2017 December). US data comes from (Child Trends Data Bank, 2015). Black, American Indian/Alaskan Native, White, and Asian/Pacific Islander are all non-Hispanic. England, Scotland, Netherlands data come from Euro-PERISTAT (Zeitlin, Mohangoo, &

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Table 5. Odds Ratios of the effect of no/late prenatal care to first trimester prenatal care to SIDS/SUID, by US racial/ethnic group

	OR no prenatal care/First Trimester care (95% Confidence Interval), SIDS	OR Third Trimester prenatal care/First Trimester care (95% Confidence Interval), SIDS	OR no prenatal care/First Trimester care (95% Confidence Interval), SUID	OR Third Trimester prenatal care/First Trimester care (95% Confidence Interval), SUID
Black	2.20 (1.80, 2.68)	1.58 (1.35, 1.85)	2.66 (2.36, 3.00)	1.65 (1.49, 1.82)
AI/AN	<i>1.36 (0.55, 3.34)</i>	<i>1.12 (0.65, 1.93)</i>	<i>1.59 (0.90, 2.79)</i>	<i>1.24 (0.87, 1.77)</i>
White	3.87 (3.24, 4.61)	2.49 (2.21, 2.81)	4.04 (3.57, 4.57)	2.60 (2.39, 2.83)
Hispanic	2.94 (2.23, 3.89)	0.67 (0.36, 0.54)	3.59 (3.01, 4.27)	2.01 (1.74, 2.33)
Asian/PI	2.88 (1.07, 7.81)	3.15 (2.02, 4.91)	4.43 (2.48, 7.92)	2.45 (1.72, 3.49)

Note. Black, AI/AN, White, and Asian/PI are all non-Hispanic. Numbers in italic indicate failure to reach statistical significance. AI/AN: American Indian/Alaskan Native; OR: odds ratio; PI: Pacific Islander; SIDS: sudden infant death syndrome; SUID: sudden unexpected infant death. Source of prenatal care comes from (Centers for Disease Control and Prevention & National Center for Health Statistics, 2017 December).

Reference

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