

Energy Drink Consumption in the Australian Construction Industry: A Risky New Trend?

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Abstract: Construction workforces' health behaviors have received little attention compared with work injury risks and management. Formulated caffeinated beverage (FCB) (energy drink) consumption is relatively new to construction sites and excessive consumption may have effects on both health and safety owing to known short- and long-term physiological responses. This study contributes to understanding drivers and deterrents of caffeine and FCB consumption in construction. Data were collected from workers at six construction sites in Queensland, Australia, using mixed-method research design involving semistructured interviews (70) and quantitative surveys ($n = 250$). Convergent interviewing underpinned by the theory of reasoned action was used to analyze qualitative interviews. Bivariate logistic regression analyses were conducted to examine determinants of caffeine and FCB consumption. Work hours were associated with caffeine consumption >210 mg/day ($\beta = -0.046$, $p = 0.037$). Qualitative results indicate energy drinks are consumed widely and regularly on site, with stress and attempts to manage the pace, timing, and intensity seen as drivers for consumption. In combination, these findings suggest management of FCBs on construction sites requires more attention as a potential health hazard. DOI: [10.1061/\(ASCE\)CO.1943-7862.0001339](https://doi.org/10.1061/(ASCE)CO.1943-7862.0001339). © 2017 American Society of Civil Engineers.

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Introduction

Like most industrialized countries, the construction industry in Australia has a reported higher incidence of short-term, risky alcohol consumption than most other industries and has long been associated with a drinking culture (Alwan 2011; Berry et al. 2007). Explanations of why this drinking culture exists generally revolve around the entrenched work organization practices in the industry and the nature of the workforce. Construction is a male-dominated sector with a large proportion of young workers (ABS 2011); men are known to adopt less healthy lifestyles and less health-promoting behavior than their female counterparts (Courtenay 2000; Levant et al. 2009) and young males are more likely to drink to excess than older adults (Australian Institute of Health and Welfare 2011). It is well accepted that the work environment in construction is highly demanding and stressful (Chan et al. 2012; Wang et al. 2016), with longer than average working hours compared with most other industries (ABS 2013). General stresses on site are compounded by tight deadlines and severe financial penalties for failing to meet set targets resulting in a cycle of activity with peaks and troughs in production requirements and work hours and limited fixed or long-term employment (Lingard et al. 2012). Consuming alcohol to alleviate tension resulting from exposure to these work stressors is a common practice (Bowen et al. 2013) and consistent with the widely cited Tension Reduction Theory (Conger 1951; Pabst et al. 2010).

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This article focuses on evidence for a new drinking behavior risk in construction, formulated caffeinated beverages (FCBs) (Australia New Zealand Food Standards Code Standard 2.6.4), commonly termed energy drinks. The health effects of FCBs have not been fully established, however it is known that long-term exposure to the various components of these drinks is likely to result in significant alterations in the cardiovascular system (Higgins et al. 2000). Energy drink consumption is also associated with alcohol-related problems and dependence (Arria et al. 2011). Work safety is often researched in the construction sector because it has higher injury rates than most other sectors (Loudoun 2010; Safe Work Australia 2012). However, as a research topic, construction worker health and well-being has received scant attention to date (Hengel et al. 2013), possibly owing to the clear measurable costs associated with injury (Iles et al. 2012). The current research investigates consumption patterns of caffeine in general, and FCBs in particular, with a view to providing insight into drivers and deterrents for consumption and impacts of consumption.

Formulated Caffeinated Beverages in Construction

In Australia, formulated caffeinated beverages are consumed across the population (ABS 2012). Food Standard 2.6.4 regulates the consumption of caffeine per beverage between 145 to 320 mg/L of caffeine (Australia New Zealand Food Standards Code Standard 2.6.4). Food composition data approximate FCBs to have 32 mg/100 g of caffeine compared with cola soft drinks with 9 mg/100 g (FSANZ 2011). While mg/mL of caffeine is regulated in FCBs in Australia, the total amount of caffeine per serving size is not (Pollard et al. 2015). Soft drink serving volumes have increased in size in Australia (Hector et al. 2009), including FCBs. In this study, 600-mL bottles or cans of energy drinks were identified as available in vending machines in all participating construction sites. Considering these elements together, FCBs have the potential to be a significant source of caffeine toxicity, which is reported as rising in Australia, with severe side effects including cardiac and

76 neurological toxicity, palpitations, tremor, seizures, hallucinations,
77 and arrhythmias (Gunja et al. 2012).

78 In the Australian population, men consume more FCBs than
79 women on average with 8.3 g/day consumed compared with
80 2.3 g/day (ABS 2012). Construction may have a higher consump-
81 tion than other groups when factoring in its predominantly younger
82 male demographic, which is that targeted by FCB manufacturers
83 with claims their products provide “. . . psychoactive, performance-
84 enhancing and stimulant drug effects” (Reissig et al. 2009, p. 7).
85 The colloquial reference of FCBs as energy drinks further promotes
86 perceptions of their stimulant effects. For U.S. college students,
87 reasons cited for FCB consumption include insufficient sleep and
88 to increase energy (Malinauskas et al. 2007). In U.S. military per-
89 sonnel, intake was cited as being for improving mental alertness,
90 mental endurance, and physical endurance, with 65% of those re-
91 porting use also reporting a side effect (Stephens et al. 2014).

92 It is well known that young males are the target group for FCBs,
93 but little is known about their use in construction. There can be no
94 doubt that consumption of FCBs is on the rise, with a 351% in-
95 crease in consumption between 2001 and 2010 (Canadean 2011)
96 and, in broader research on young males, higher risk-taking and
97 masculinity scores were associated with FCB consumption (Miller
98 2008). Despite this research, consumption patterns among con-
99 struction workers of FCBs are unknown. For example, it is not
100 known whether construction workers disproportionately and ex-
101 cessively use these products on their own or together with other
102 caffeine beverages such as coffee and milk-based drinks, or the pos-
103 sible implications for health and safety on site should this be the
104 case. Information about beverage consumption and levels of con-
105 sumption in construction is important to characterizing industry
106 safety risks as well as health risks.

107 There are several safety risks that could be hypothesized to exist
108 with high caffeine consumption in the construction industry. For
109 example, excessive caffeine consumption could cause incidents if
110 a palpitation or tremor occurred when working. Caffeine consump-
111 tion is also known to be sleep disruptive (Roehrs and Roth 2008)
112 and reduce sleep homeostasis and sleepiness (Landolt et al. 2004).
113 Given long working hours and reduced sleep hours in construction
114 projects, increasing sleep debts further by consumption of caffeine
115 may reduce recovery further (Lingard et al. 2008; Townsend et al.
116 2012). Poor mental health is also a known risk among construction
117 workers (Love et al. 2010; Wang et al. 2016). In Australia, the only
118 caffeine recommendation for nonpregnant adults is that consum-
119 ing more than 210 mg daily may increase anxiety (Smith et al.
120 2000), which is marginally above one standard 600-mL can of FCB
121 (FSANZ 2011).

122 From the viewpoint of physical health and chronic disease risk,
123 FCBs might also pose risks. Construction workers have higher rates
124 of cardiovascular risk factors including obesity, high blood pressure,
125 smoking, and harmful alcohol consumption (Alwan 2011) than
126 those of the standard population. Energy-dense and nutrient-poor
127 foods and beverages contribute to the development of obesity and
128 high blood pressure. Obesity is frequently estimated with body
129 mass index (BMI) (Flegal et al. 2012), a commonly used measure
130 of body fat based on height and weight that applies to adult men
131 and women. Sugar-sweetened beverages including soft drinks have
132 been linked to obesity (Malik et al. 2010). Formulated caffeinated
133 beverages fit within the soft drink category (Hector et al. 2009). The
134 avoidance of cordials and sports drinks is recommended in hydra-
135 tion strategies due to their high energy (caloric) content (Hedrick
136 et al. 2012). Formulated caffeinated beverages have greater sugar
137 content on average than both cordial and sports drinks (FSANZ
138 2011), therefore they need to be avoided in hydration strategies ir-
139 respective of caffeine. Given this research, it seems reasonable to

conclude FCB consumption could further exacerbate construction
workers’ risk of dehydration in the short term and developing car-
diovascular disease (CVD) and diabetes in the long term through
increased energy intake.

In sum, this review of existing evidence of the implications of
FCB consumption on work health and safety highlights that there
are many unknowns about their long- and short-term use in con-
struction. Nonetheless, in combination the existing evidence sug-
gests there are good reasons for not wanting use to extend to misuse
and dependence. Furthermore, it suggests that investigation to
understand consumption patterns and drivers is needed to develop
effective strategies to manage consumption on site. Investigation to
understand consumption patterns and drivers is needed to develop
these strategies. The theory of reasoned action (TRA), which ex-
plains behavior as determined by a person’s evaluations of the
behavior (attitude) and perceptions of social pressure (subjective
norm), offers a guiding framework for such an investigation (Ajzen
and Fishbein 1980).

The theory of reasoned action has long been used as a model to
predict behavioral intentions and/or behavior in the field of health
(Fishbein 2008; Godin and Kok 1996; Head and Noar 2014). Addi-
tional variables have been proposed and tested for inclusion in,
or expansion of, the theory since it was first postulated almost 40 years
ago. However, at its most simple level, a reasoned action approach
to the explanation and prediction of behavior assumes that people’s
behavior follows reasonably from their beliefs in favor of or against
performing the behavior (Ajzen and Fishbein 1980). Applying the
reasoned action approach to FCB consumption, a simple explan-
ation of an individual’s motivation to drink would center on their
positive personal judgments about the perceived consequences of
performing the behavior (such as “I expect to have a lot more en-
ergy if I have a FCB”) together with their views about what im-
portant specific referent individuals think they should do (such as
“more experienced people than me drink energy drinks on site,
therefore it must be a good idea”). These beliefs represent an im-
portant component of motivation to drink, while negative judg-
ments (such as “I expect to have health problems if I consume
large amounts of FCBs” or “my site manager only drinks water on
site, therefore I should too”) provide motivation to restrain.

Drawing on TRA, the present study develops existing knowl-
edge by investigating perceived influences and drivers of caffeine
and particularly FCB consumption in Queensland, Australia. The
research draws on data from managers and employees of both prin-
cipal contractors and subcontractors in project-based construction.
The analysis seeks to provide greater insight into patterns of con-
sumption on site as well as influences and perceived impacts of
consumption. Previous research has identified time pressures and
working hours as impacting health decisions in construction
(Townsend et al. 2016) and work hours usually differ by trade with
structural trades generally having longer work hours in Australia
than finishing trades (ABS 2011). Work influences are focused on
in this study because these are potential modifiable determinants.
Demographic variables including age and obesity were included
for the previously stated reasons. Salary was also included because
food costs impact purchasing and salary may therefore be a driver
of consumption (Andreyeva et al. 2010). Therefore, associations
between work hours and trade type and caffeine and FCB con-
sumption were investigated.

Methodological and Theoretical Framework

This examination of caffeine and FCBs consumption in con-
struction adopted Ajzen and Fishbein’s (1980) theory of reasoned

201 action. At its core, this theory holds that an individual's assessment
202 of outcome expectations determines behavior. Whether perceptions
203 about the desirability and likelihood of an outcome are valid is irrel-
204 evant to determining behavior; to influence behavior, the beliefs
205 simply need to be held. This research, therefore, combined infor-
206 mation about patterns of FCB consumption in construction with
207 perceptions about drivers of these patterns as well as their influence
208 on activities and behaviors on worksites.

209 This focus, as well as the chosen theoretical approach, were con-
210 sidered when deciding on which methodological strategy to adopt
211 for the study. A mixed-methods pragmatic approach (Onwuegbuzie
212 and Leech 2005) was adopted with both qualitative and quantita-
213 tive data because this approach offers the opportunity of minimiz-
214 ing limitations of a single approach by combining methods with
215 complementary strengths (Abowitz and Toole 2010). The quanti-
216 tative study allowed the collection of data about consumption pat-
217 terns relevant to a wide cross section of ages and trades, while the
218 qualitative responses provided in-depth, rich information about per-
219 ceived influences and drivers of consumption.

220 Phenomenology guided the qualitative research process because
221 this methodology promotes investigation of the lived experiences
222 of participants under investigation (Creswell 2007). It also encour-
223 ages an interdisciplinary approach to the topic under investigation,
224 which was deemed necessary given the limited research in this area
225 and the aim to draw insights and perceptions from a wide range of
226 managers and employees.

227 Method

228 Construction workers and managers on six construction projects in
229 Brisbane, Australia, participated in the study. These projects were
230 chosen to ensure consistency across build type and size. All sites
231 were completing project-based, large multistory builds of commer-
232 cial office space or mixed residential and retail space. Qualitative
233 and quantitative data were collected between mid-2014 and mid-
234 2015. Principal contractors and union delegates on each site made
235 the initial request for participation in the study to all subcontract-
236 ors and principal contractor employees at start-up meetings and
237 lunch breaks. The researchers used subsequent lunch breaks to fol-
238 low up these requests and distribute surveys. Contact details were
239 collected in surveys and interviews were conducted at a later date
240 during work hours using a semistructured approach as described by
241 Fontana and Frey (1994).

242 Twenty-eight contractor managers, 15 subcontractor managers,
243 and 27 trades workers were interviewed individually (45 in total) or
244 in small groups (25 in total). A purposive sampling strategy was
245 used to ensure representation from each level of the hierarchy and
246 from the major trades—concreters, electricians, plasterers, painters,
247 plumbers, bricklayers, and formwork carpenters—and position
248 titles at each level—contracts managers, site managers, site-based
249 and corporate work health and safety managers, and officers from
250 the principal contractor and from subcontracting firms, supervisor,
251 and team leaders. All interviewees were male, reflecting the current
252 usual worksite demographic of the industry.

253 Interviews began with broad questions about healthy lifestyle
254 behaviors and health and well-being to introduce the topic and
255 because this study formed part of a larger study about nutrition
256 and dietary habits in construction. Using a similar order, partici-
257 pants were then asked specifically about beverage intake on site;
258 any perceptions of effects of beverages on site, particularly safety
259 and productivity; site influences; and barriers or facilitators for bev-
260 erage consumption. Managers were also asked about their role and
261 any perceived responsibilities with regard to beverage intake and

262 productivity and safety on site. Three researchers performed the
263 interviews; notes were made during the interviews to assist with
264 postinterview discussions, but interviews were also audio recorded
265 and subsequently transcribed. Data collection continued until the
266 researchers reached theme consensus and all researchers agreed
267 no new information was emerging from the interviews and repeti-
268 tion of concepts became consistent.

269 Quantitative data were collected on demographic information,
270 work information, and beverage consumption. Data about drink
271 consumption type, frequency, and amounts were collected using
272 the previously validated BEV-15 survey (Hedrick et al. 2012), with
273 15 items summing the frequency per week by the amount con-
274 sumed each time. The BEV-15 was modified to 12 items by the
275 project's research dietitian (Katherine Markwell) to include drinks,
276 terms, and volumes consistent with the Australian setting, and to
277 allow caffeine consumption calculation. Respondents were asked
278 whether drinks were consumed in combination with food or as
279 a meal replacement. Demographic information about age, gender,
280 salary, type of job, and education was also collected from respon-
281 dents along with information about average number of work hours
282 generally performed per week including overtime and self-reported
283 BMI. Caffeine consumption by beverage type and total caffeine
284 consumption was calculated by allocating caffeine/mL numerals
285 using values for beverages in the AUSNUT 2011-13 AHS Food
286 Nutrient Database (FSANZ 2011). Trades were categorized as
287 finishing and formwork (e.g., painter, electrician, tiler, plasterer,
288 plumber, window fixer, glazier, air conditioning, stone mason,
289 cabinet maker) or initial and structural (carpenter, scaffolder, steel
290 fixer, crane operator or dogman, bricklayer, blocklayer, concreter,
291 laborer, stressor).

Data Analysis Strategy

293 The process used for analysis of the qualitative data formed a
294 version of convergent interviewing as described by Jepsen and
295 Rodwell (2008). Analytical conversations between the researchers
296 were performed after the interviews at each site to identify prelimi-
297 nary themes and investigate concepts (Goetz and LeCompte 1981).

298 For quantitative data, bivariate logistic regression analyses
299 were conducted to examine determinants of caffeine consumption.
300 Caffeine consumption was dichotomized to those consuming more
301 or less than the daily recommended maximum caffeine intake
302 (<210 mg/day).

303 Of the 250 surveys completed, there were 239 male and 6
304 female respondents (5 missing). Missing values were generally
305 random, but age and salary appeared to have intentional noncom-
306 pletion with 56 missing cases each (not the same cases). Missing
307 drink data appeared unintentional with serving sizes sometimes
308 missing. To reduce the impact of missing variables on power in the
309 analyses, missing serving size values were replaced with the modal
310 choice by cohort respondents or the most frequently available drink
311 serving available on sites [using the serving size expertise of the
312 project research dietitian (Katherine Markwell)]. Data were then
313 analyzed in two different models; one with work conditions that
314 were hypothesized to impact caffeine consumption (work hours,
315 structural or finishing trades, complete data $n = 156$) and one with
316 these and demographic covariates included (age, salary, and self-
317 reported body mass index, complete data $n = 98$). Gender was
318 excluded due to the low numbers of females. The separation into
319 two models was to allow the investigation of work influences (work
320 hours and trade type) while reducing the impact of missing dem-
321 ographic data for age and salary. There was low multicollinearity
322 between trades or work hours ($r=0.173$, $p = 0.035$). Descriptive

323 frequencies and trends were also calculated. Analyses were per-
324 formed in *SPSS Version 22*.

325 Results

326 Quantitative Data

327 Of the 156 surveys for the first model, there were 153 male respond-
328 ents (98%), 2 female respondents (1%), and 1 missing response.
329 Demographic characteristics of the sample along with caffeine con-
330 sumption data are presented in Table 1.

331 Binary logistic regression analyses for caffeine consumption
332 **11** are shown in Tables 2 and 3. In Model 1 (Table 2), higher working
333 hours were cross-sectionally associated with higher caffeine con-
334 sumption ($\beta = -0.046$, $p = 0.037$). Trade type (structural or fin-
335 **12** ishing) was not associated with caffeine consumption ($\beta = 0.109$,

$p = 0.799$). In Model 2 (Table 3) with additional demographic
covariates, higher working hours were still cross-sectionally asso-
ciated with higher caffeine consumption ($\beta = -0.064$, $p < 0.022$).

A total of 31% of workers indicated that they consumed more
than one energy drink a week and younger age was associated with
this trend ($\beta = -0.035$, $p = 0.017$, $n = 214$). The relationship
between age and FCB consumption can be seen descriptively in
Fig. 1.

Qualitative Findings

Thematic content analysis of interview data resulted in two main
drivers of consumption consistent with the theory of reasoned
action: Individual assessments of the degree to which caffeine
and FCB consumption assists with managing time pressures and
with managing daily work pressures in the short term and the long
term. Negative views about mood fluctuations, attention, and safety

Table 1. Sample Characteristics ($n = 156$)

Variable	Value
T1:1	
T1:2	Average age [M (SD)] ($n = 129$)
T1:3	Permanent staff (%) ($n = 154$)
T1:4	Salary (\$/fortnight) [M (SD)] ($n = 126$)
T1:5	Highest level of education ($n = 153$)
T1:6	Completed high school or some secondary education (%)
T1:7	Completed trade or tertiary training (%)
T1:8	Self-reported BMI (kg/m^2) [M (SD)] ($n = 142$)
T1:9	Average daily caffeine consumption (mg/day) [M (SD)] ($n = 156$)
T1:10	Daily caffeine intake (mg/day) [median (range)]
T1:11	Caffeine from FCBs ^a (%) [M (SD)] ($n = 148$)
T1:12	Caffeine from caffeinated soft drinks (%) [M (SD)] ($n = 148$)
T1:13	Caffeine from coffee or tea (%) [M (SD)] ($n = 148$)
T1:14	Caffeine consumption >210 mg/day ^b (%) ($n = 29$)
T1:15	Working hours [M (SD)] ($n = 156$)
T1:16	Trades
T1:17	Structural trades (formwork carpenters, scaffolders, steel fixers, crane operators, bricklayers, blocklayers, concreters, laborers) (%)
T1:18	Finishing trades (painters, electricians, tilers, plasterers, plumbers) (%)

Note: n values are given if missing data; M = mean; SD = standard deviation.

^aValues identified or averaged by the research dietitian (Katherine Markwell) using AUSNUT 2011-13 AHS Food Nutrient Database (FSANZ 2011);
estimated values of FCBs = 32 mg/100 g; caffeinated soft drinks = 9 mg/100 g; coffee or tea = mean 31.8 mg/100 g.

^bCaffeine intake dichotomized to ≥ 210 mg daily or < 210 mg daily (Smith et al. 2000).

Table 2. Relationship between Trade Types and Work Hours with Caffeine Consumption Less Than or above 210 mg: Model 1

Predictor	B (standard error)	Daily caffeine consumption ($n = 156$)	
		Wald	OR
T2:1			
T2:3	0.109 (0.429)	0.105	1.116, $p = 0.799$
T2:4	-0.046 (0.022)	4.727	0.955, $p = 0.037$
T2:5	—	$R_{cs}^2 = 0.032$, $R_N^2 = 0.051$, $P = 0.081$	

Note: Significant ($p < 0.05$) associations appear in bold text; OR = odds ratio, adjusted.

Table 3. Summary of Binary Logistic Regression Analysis for Variables Predicting Caffeine Consumption, Controlling for Background Variables: Model 2

Predictor	B (standard error)	Daily caffeine consumption ($n = 98$)	
		Wald	OR
T3:1			
T3:3	0.052 (0.032)	5.244	1.015, $p = 0.430$; 1.053, $p = 0.107$
T3:4	0.000 (0.00)	4.075	1.000, $p = 0.388$; 1.000, $p = 0.044$
T3:5	-0.061 (0.703)	0.008	1.114, $p = 0.786$; 0.940, $p = 0.930$
T3:6	-0.064 (0.028)	5.244	0.964, $p = 0.070$; 0.938, $p = 0.022$
T3:7	0.071 (0.050)	2.037	1.026, $p = 0.498$; 1.074, $p = 0.153$
T3:8	—	$R_{cs}^2 = 0.107$, $R_N^2 = 0.197$, $P = 0.050$	

Note: Significant ($p < 0.05$) associations appear in bold text; OR = odds ratio, raw and adjusted.

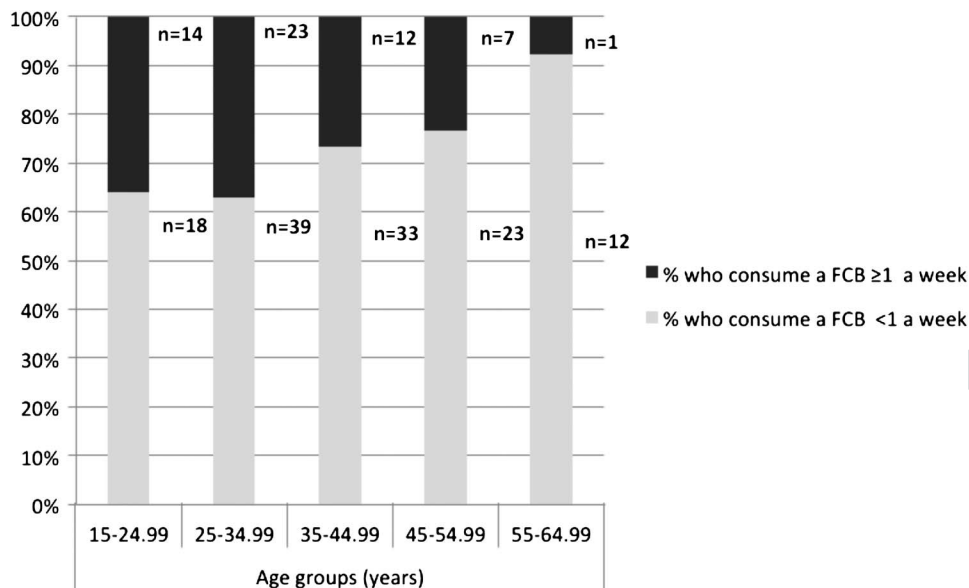


Fig. 1. Age groups and FCB consumption frequency ($n = 182$)

F1:1

impacts on site associated with hydration were identified as deterrents for consumption.

Interview data highlight the increasing role FCBs play in construction. A common view expressed by site managers was that energy drinks are the norm. One site manager considered the influence of energy drinks as so persuasive that it had taken over from the traditional soft drink and cigarette culture onsite. As he explained: “The energy drinks are a change, used to be Coke and cigarettes, but smoking is banned on site now and the energy drinks are new.”

There were consistently held views by managers and workers that FCBs affected the performance of people on site, with people consuming multiple drinks throughout the day being easy to identify. One site manager noted: “You can really tell the ones on the energy drinks. They are wired and talkative by the end of the day.”

And a plasterer: “You can tell the people on the energy drinks. Their body language gives it away—pacing and agitation and the crap they talk; their appearance too.”

Generally, although workers noted that those consuming energy drinks were difficult to work with, only managers expressed concern about the impact of increasing consumption on workers and on safety on site. These concerns largely centered around workers’ long-term general health and also on more immediate concerns about hydration onsite. This concern about hydration resulted in most managers thinking energy drink consumption did or could fall within their area of responsibility. The impact of energy drinks on weight and broader health indexes, however, were not generally perceived as safety risks by both workers and managers and were considered an individual’s responsibility as noted by the following managers:

[Energy drinks] ah, that’s more of a, a health risk. That’s more of an occupational health and safety thing for me if you know what I mean. You get high on those things and when you come down, you become very very down you know.

I’ve got some guys who I actually believe they’re energy drink addicts, and I do speak to them about it, but once again, 98% of the time like . . . it’s laughter is the reply. Once again, that’s a hydration thing for me. The energy drinks actually have the opposite effect, they do, I’m pretty sure it’s proven, dehydrate. rather than rehydrate, so I try to get them to cut down. Obviously I can’t stop them, but I try to get them to

cut down and drink more water. That’s part of my role here definitely, just to keep them on their feet all day.

Due to the perceived risk of safety incidents, one subcontractor company had implemented rules against energy drink consumption. As their manager explained, “I find a fair few people drinking energy drinks um, like it’s water. My employees, don’t, aren’t allowed to drink energy drinks, when it’s hot they just drink, really too much of them. It just makes you more thirsty, your body’s going a hundred miles an hour. You know that stuff’s not good for you. Because we had a fair few, um, fair few incidents with them . . . There’s quite a lot of concreters, they drink a lot of it they get hot and sweaty and don’t enough, you know, water, they just collapse. Overexert yourself.”

Importantly, while not every manager and worker expressed concern over the amount of FCBs consumed on site, no one interviewed indicated that they had a positive impact on performance or well-being beyond a few noting they helped them temporarily when they felt sluggish.

Supporting the survey trends in Fig. 1, the consumption of FCBs was seen by most as more common for less experienced and younger workers than older workers, possibly reflecting advertising campaigns targeted at young people but also a lack of experience. As one site manager explained, “You see the young blokes smashing pies and energy drinks every day. The older blokes are more experienced and know what makes them feel good. When you’re young you’ve got iron guts and (you think you’re) invincible.”

And older trades workers:

The younger generation—say under 30 and apprentices—live on Red Bull. They have 1–2 a day. Certainly energy or hipster drinks replace food.

When the young guys come on site, first thing in the morning and they’ve got two “Red Bulls” in their hands, they’re full of energy. And then by 10 o’clock they are miserable and want to go home

Looking at drivers for FCB consumption patterns on site, reasons cited generally revolved around stress and attempts to manage the pace, timing, and intensity of work.

430 **Time Pressures**
431 The first area that workers reported turning to energy drinks relates
432 to the early start times combined with long work hours and long
433 commutes to work. Numerous workers indicated they often feel
434 time and workload pressures due to deadlines, and this has a real
435 influence on their decision making on a daily basis. Interviewees
436 explained that energy drinks are replacing breakfast or other meals
437 so that they can sleep a little longer or because they are not organ-
438 ized to have breakfast, as noted by the following managers:

439 I've got some guys I know who don't eat bugger all all day but
440 they do survive on the Red Bulls.

441 They've got some though that don't even eat—energy
442 drinks and one big dinner. One of the guys is 19 and he drinks
443 energy drinks all day then a big dinner.

444 **14** And trades workers themselves: "Energy drinks a huge for
445 breakfast. Quick, easy, and make you feel good—for a while any-
446 way. We get energy drinks at the servo."

447 The nature of working hours within the industry, combined with
448 employees often working on projects at least 1 h of driving time
449 from their house, meant that 4–4:30 a.m. was a common wake-up
450 time for these workers. Numerous employees said their body is not
451 ready for food at 4 a.m. and the long commute and work days pro-
452 vided an added stress influencing the time and energy available to
453 eat breakfast. For some, energy drinks were consumed as a caffeine
454 pickup particularly on the long drive home. As these trades workers
455 explained, "It is a high energy job and early starts so it is tempting
456 to skip breakfast. Getting up 1/2 hour is hard. I eat on the run.
457 When I eat breakfast so early it just feels like an extra meal so
458 I get hungry as if I haven't had it anyway. Coffee or energy drinks
459 get people through the day."

460 Because of time pressures, convenience when making beverage
461 choices was reported to impact consumption as noted by these
462 managers: "A lot of people they work long hours they're tired when
463 they get home. [The] last thing they'll think about is making a
464 healthy lunch. Not laziness, that's probably the wrong word for it,
465 tiredness."

466 **Work Pressure**

467 The second driver of FCB consumption identified in the data was
468 beliefs about strategies to manage workload work pressure. It was
469 very clear from the interviews that workers used FCBs in an at-
470 tempt to cope with stress associated with work pressure, particu-
471 larly the physical requirements of their job. These are decisions
472 that had a direct impact on drinking habits as noted by these trades
473 workers:

474 They find they've got to do it [drink energy drinks], because
475 they're pushed, they're pushed to do everything fast. They're
476 still working hard but they're . . . well you know, the foreman
477 can only influence them for so long before your body gets
478 tired, instead of slowing up—there's no room for that you
479 know—take something and make yourself continue at that
480 level.

481 People definitively need the sugar rush of Coke or energy
482 drinks.

483 Most managers described seeing energy drinks as a short-term
484 fix with the end result being a cycle of multiple drinks being con-
485 sumed throughout the day: "If their energy is running out they
486 might grab an energy drink but they're a quick fix—you then need
487 another one in an hour."

This view was supported by many trades workers themselves:
"You've just had that energy drink—you'll be 100% of 10 min then
you'll crash."

Coupled with this comment, the habit-forming or addictive
aspect of energy drinks was a concern for some trades workers:
"Fatigue, tiredness, wanting a sugar boost. It becomes a habit you
can't get out of."

497 **Discussion**

498 This study provides a detailed picture of energy drink and caffeine
499 consumption on urban Australian project construction sites. Results
500 indicate that energy drinks are consumed widely and regularly on
501 site, with stress and attempts to manage the pace, timing, and in-
502 tensity seen as drivers for consumption. Although FCBs are con-
503 sumed on worksites and are consumed by younger workers as
504 reported by both the quantitative and qualitative data, at this point
505 age is not the main contributor to caffeine intake. The most impor-
506 tant trend was that caffeine consumption is associated with greater
507 work hours. This became significant with trade types included in
508 the model; work hours are likely to be influenced by trade type and
509 this by extension influences caffeine consumption. It is clear from
510 both the quantitative and qualitative data that caffeine usage ap-
511 pears to be used by construction workers to modify and cope with
512 working conditions. This should be considered in planning health
513 promotion interventions and preventing longer-term health issues
514 on construction sites.

515 These findings suggest the theory of reasoned action (Ajzen and
516 Fishbein 1980) represents a useful guiding framework to explain
517 FCB consumption in construction. Results indicate that positive
518 personal judgments about caffeine and FCBs assisting with man-
519 aging time pressures and daily work pressures in the short term and
520 the long term represent important components of the motivation
521 to drink. Conversely, negative judgments about mood fluctuations,
522 attention, and safety impacts on site associated with hydration re-
523 present important components of the motivation to restrain from
524 consumption. The disparity between evidence on the risks posed by
525 FCB consumption and the perceptions of workers reported in this
526 study about their perceived benefits suggests there is an opportunity
527 for education strategies to influence personal judgments.

528 The findings here point to interactions between the organization
529 of work and health behaviors on site by way of beverage choices.
530 Healthy work organization has received growing attention in re-
531 cent years, including some construction sites, largely owing to
532 the growing recognition and understanding of the determinants
533 of these environments and organizational costs when they are
534 not managed (Story et al. 2008). It focuses on the impact of the
535 structure and management of work processes—such as job design,
536 scheduling, management, organizational characteristics, and poli-
537 cies and procedures—on the health and well-being of employees
538 creating healthy or unhealthy work systems (DeJoy et al. 2006,
539 2010). Broad research shows that stressful work environments and
540 associated work-life interference are directly related to higher lev-
541 els of sickness absence and increased turnover (Bergström et al.
542 2007), and, at an individual level to psychological strain, psychi-
543 atric disorders and substance abuse (Carlson et al. 2011; Hammer
544 et al. 2004; Siegrist 2008; van den Berg et al. 2008). These findings
545 extend this research by showing that work organization is associ-
546 ated with FCB consumption. Construction workers and managers
547 in this sample identified work organizational influences that under-
548 pin health behaviors on site, with an obvious example being the
549 presence of vending machines stocking FCBs on construction sites
550 in Australia (Townsend et al. 2016).

In many countries there is a lack of regulation with FCBs. In the United States, public health measures including improved labeling, regulation, and education have been advocated (Arria and O'Brien 2011; Thorlton et al. 2014). Such discussions have led to industry concerns of product liability and suggestions for prophylactic action (Peterson 2013). In Australia, the situation is dissimilar, with labeling and regulations being more stringent. Food Standards Australia New Zealand require formulated caffeinated beverages to be labeled with warnings about caffeine consumption and suggested maximal consumption (Code Standard 2.6.4). While this is higher than that of other caffeinated soft drinks, it is not unregulated. However, findings here suggest these regulations are not effective in preventing overconsumption of FCBs for construction workers, who report using these drinks to try to manage their stressful working environment and as an alternative breakfast.

The nature of project-based work in construction presents considerable challenges for work hours. There are usually long working hours, early start times, 6-day working weeks, and potentially long commute times depending on site location changes. Long working hours and early start times are associated with reduced sleep times (Basner et al. 2013; Chatzitheochari and Arber 2009). Managers in this study did not raise sleep loss as a concern—although this may reflect a lack of knowledge of the impacts—but prolonged sleep loss has been identified to impact multiple health parameters including depression and chronic diseases (Porkka-Heiskanen et al. 2013).

Construction workers are not generally considered shift workers unless their shift schedules include nightwork. However, these exposures indicate that construction workers may be more likely to accumulate a sleep debt than day-shift workers with later start times and a shorter shift. Previously cited reasons for FCB consumption include overcoming fatigue and improving physical performance, particularly among those on atypical schedules (Jay et al. 2006; Malinauskas et al. 2007; Stephens et al. 2014). Results here suggest construction workers have similar perceived reasons to use FCBs; that is, positive beliefs about consumption assisting with overcoming fatigue associated with work schedules and the generally physical nature of the work, and to improve performance. Marketing FCBs as energy drinks is one explanation of where these beliefs might stem. Additionally, the workforce is generally younger and male—the target group for FCB marketing—so any risks of consumption may be disproportionate compared with risks of consumption in the general population.

The reported performance benefits of caffeine consumption may be due to supplying a substance from which the body is withdrawing, rather than independent improvements, per se (James and Rogers 2005) so irregular and changing caffeine consumption, as potentially seen within changing daily work hours in construction, may impact productivity and safety through physiological mechanisms more than a steady dose of caffeine consumption. Caution is therefore advised in consumption. Portion sizes have increased in some FCB brands along with availability on site, increasing the likelihood of consuming more caffeine. Without this easy access, workers would otherwise have required prior purchase to consume them, a difficult task in the short and infrequent work breaks described by many workers.

Like alcohol, excessive consumption of caffeine is a known risk for heat stress (Rowlinson et al. 2014). Prevention of heat stress is important for subtropical working conditions as seen in many parts of Australia. Results indicate that the impact of FCB consumption on hydration and associated heat stress are of concern for managers in construction and something they see as part of their responsibility to manage. Caffeine has many physiological effects and has been recommended for athletes to improve sports performance

(Goldstein et al. 2010), but some argue that on balance FCBs should not be consumed during sport (Higgins et al. 2000). For a physical work setting where hydration affects cognition and safety risks, similarly FCBs are not ideal. Further, it should be considered that while sources of caffeine such as tea and coffee have components that have known cancer-prevention effects, FCBs and caffeinated soft drinks do not because caffeine is a supplement to the beverage and the other main component besides water is added sugar, also known to be detrimental to health outcomes. It is unknown if FCBs have displaced drinks that were similar in caffeine content in Australian diets (e.g., a can of Coke) or noncaffeinated beverages (e.g., water, regular soft drink, juice). Caffeinated energy drinks are categorized as sugar-sweetened beverages (SSBs), the consumption of which contribute to weight gain and chronic disease risk including cardiovascular diseases (Hu and Malik 2010; Malik et al. 2010). The construction industry has a higher than average risk of CVD due to predisposing risk factors (Alwan 2011). Thereby, their regular and high usage of energy drinks could further exacerbate workers' elevated risk of developing CVD. From the viewpoint of worker physical health and work health and safety, FCBs as a source of excessive energy may pose other risks, with obesity being linked to greater accidents in other industries (Anderson et al. 2012) and having other potential health and safety risks identified in a review by Schulte et al. (2008).

A limitation of this study is that daily caffeine consumption and work hours were based on self-reported data and that there were a large amount of missing demographic data, particularly age and salary. This is not surprising given both are likely to be sensitive in the industry owing to the unreliable nature of work and the physical nature of many jobs making age discrimination more likely (Van Dalen et al. 2010). Despite these limitations, caffeine is commonly known and used as a performance enhancer for fatigue so the observed relationships between higher working hours with higher caffeine consumption appear plausible. Further investigation of single daily consumption and work hour records may show even stronger trends in daily variation related to work load. If there is daily variance in the consumption of caffeinated beverages (including FCBs), physiological effects around performance, sleep, and mood will vary with respect to length of caffeine abstinence and tolerance.

Conclusion

This study is part of a growing body of literature investigating poor health behaviors in construction and identifies drivers of a risky new trend in construction, excessive FCB consumption. It also extends previous literature by considering the role of managers and workers in encouraging or discouraging poor lifestyle choices in construction. The theory of reasoned action provided insight into understanding motivators to consume or restrain from consuming FCBs in construction.

Many managers and workers alike indicated concern about excessive FCB on site, particularly for young male workers. These concerns largely centered on long-term workability in the industry, but also extended to short-term concerns around dehydration, fatigue, and reduced alertness at work. Motivators for excessive consumption centered on beliefs that FCBs can assist with managing time pressures and daily work pressures. Managers indicated that while many see managing FCB consumption as part of their responsibility, they find it difficult to persuade their workforce to take their concerns seriously, possibly as a result of a lack of understanding about the impact of excessive consumption on site.

675 Future research can use this information to identify behavior
676 change opportunities among different groups of workers in the con-
677 struction work environment. It can be concluded from this study
678 that raising the profile of FCBs on site to make links between ex-
679 cessive consumption and safety on site clearer is likely to be a key
680 leverage point for managers aiming to improve current practices
681 and ensure the health of their workers. As such, the findings inform
682 current practices for managing a workforce in this unique work
683 environment where maximum productivity requirements, brought
684 about by strict production targets and penalties for noncompli-
685 ance, are critical (Lingard et al. 2012). Evidence indicates that
686 long-term employment in construction is problematic, in part ow-
687 ing to increased risks for developing chronic diseases (DEEWR
688 2011; Sedighi and Loosemore 2012). Taking a more informed and
689 holistic approach to managing construction workers will have ben-
690 efits for individual firms and for longevity in the industry more
691 broadly.

692 Arguably the next step of improving workers' risk profiles in
693 these industries is reducing unhealthy lifestyle choices such as con-
694 suming excessive amounts of FCBs. While there are specific char-
695 acteristics of construction work environments that may contribute
696 to increased health risks (stress, mental illness, long hours, and/or
697 reduced sleep), drinking habits are an acknowledged key factor that
698 influences health outcomes. Formulated caffeinated beverage in-
699 take is also considered a potential safety concern in hot climates on
700 construction sites and separate to nutritional issues. In combination,
701 the findings here support previous research emphasizing the need
702 for research on health as well as safety in the construction environ-
703 ment (Loudoun et al. 2017) and suggest that attention is particularly
704 needed to address this risky new trend in construction.

705 As the third highest paid sector in Australia (ABS 2013), it is
706 reasonable to assume the health benefits associated with higher
707 economic status to be present in this group, however this is not the
708 case. Male blue-collar workers in Australia have "poorer than aver-
709 age health outcomes, increased mortality rates, disability, and seri-
710 ous chronic disease" (Kolmet et al. 2006, p. 82). Safety has always
711 been of considerable interest on construction sites, but the contin-
712 uing poor occupational health of employees and the interaction be-
713 tween the construction work environment, behavioral responses
714 from workers, and the multifaceted implications these responses
715 have on health and safety have received less consideration. There
716 has been a growing interest in improving the health of workers in
717 general, with the majority of large employers now offering wellness
718 programs (Mattke et al. 2013). Alcohol use generally forms part of
719 health campaigns in construction aimed at improving health behav-
720 iors. The results of this study suggest these campaigns, and research
721 on health behaviors more generally in construction, should be ex-
722 tended to included FCBs.

723 Data Availability Statement

724 Data generated or analyzed during the study are available from the
725 corresponding author by request. Information about the *Journal's*
726 data sharing policy can be found here: <http://ascelibrary.org/doi/10.1061/%28ASCE%29CO.1943-7862.0001263>.
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