

1 **Alcohol consumption, obesity and hypertension: Relationship patterns along different age**
2 **groups in Uganda**

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18 NMT initiated the paper and produced the first draft. All co-authors have made a great
19 contribution in different ways

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21

22 **Abstract**

23

24 **Introduction:** Uganda is experiencing a significant increase in the prevalence of non-
25 communicable diseases including hypertension and obesity. Frequent alcohol use is also highly
26 prevalent in Uganda and is a key risk factor for both hypertension and obesity. This study
27 determines the trends of frequent alcohol consumption, hypertension and obesity across different
28 age groups, and the extent to which alcohol consumption affects the two.

29 **Methods:** The data were extracted from the 2014 National Non-communicable Diseases Risk
30 Factor Survey (N=3,987) conducted among adults aged 18 to 69 years. Hypertension was
31 defined as systolic blood pressure ≥ 140 mmHG or diastolic blood pressure ≥ 90 . Obesity was
32 defined as body mass index >30 kg/m². Frequent alcohol consumption was defined as alcohol
33 use 3 or more times a week. Multivariable log binomial regression analysis was carried out for
34 each of the two outcome variables against age group and controlled for frequency of alcohol
35 consumption and few other independent factors. Non-parametric tests were used to compare
36 trends of prevalence ratios across age groups. Modified Poisson regression was use in few
37 instances when the model failed to converge.

38 **Results:** The results showed increasing trend in the prevalence of hypertension and frequent
39 alcohol consumption but a declining trend for obesity along different age groups ($p < 0.01$).
40 Frequency of alcohol consumption did not significantly modify the age group-hypertension and
41 age group-obesity relationships although the effect was significant with ungrouped age. There
42 was significance in difference of fitted lines for hypertension prevalence ratios between frequent
43 drinkers and mild drinkers and between abstainers and frequent drinkers. Alcohol consumption
44 did not have any significant effect on obesity-age group relationship.

45 **Conclusion:** The results call for more research to understand the effect of alcohol on the
46 hypertension-age relationship, and the obesity-age relationship. Why prevalence ratios for
47 hypertension decline among those who take alcohol most frequently is another issue that needs
48 further research.

49

50 *Key words: hypertension, obesity, overweight non-communicable diseases, life span, log*
51 *binomial, modified Poisson regression, robust variance estimators*

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54

55 **Introduction**

56 About 13% of the world's adult population (11% of men and 15% of women) is obese[1] while
57 32% of adults aged more than 24 years are hypertensive[2]. The prevalence of obesity and
58 obesity-related diseases including hypertension are increasing worldwide [3]. These conditions
59 lead to reduced quality of life given their protracted nature, and they also lead to premature
60 deaths, especially due to cardiovascular diseases and diabetes [4]. Once associated only with
61 high income countries, obesity and hypertension are now highly prevalent in low and middle
62 income countries, including Uganda, and are shown to be on the rise[5, 6]. The World Health
63 Organization (WHO) projects the number of hypertension cases in Sub Sahara Africa (SSA) to
64 increase substantially from an estimated 80 million in 2000 to 150 million in 2025[7].

65

66 Alcohol consumption is widely known to be associated with high blood pressure and obesity [5,
67 8-11] both of which are known to increase with age [12, 13]. However, little is known on how
68 alcohol affects high blood pressure and obesity trajectories across age. So far studies have
69 reported varying patterns of relationship between alcohol and hypertension across different age
70 groups. A study in the United States of America, found that in young people aged 18-26, blood
71 pressure reduced among those who took 2-3 drinks a day but rose higher with more or less
72 alcohol intake [14]. In Germany a study found a linear relationship between alcohol intake and
73 blood pressure for only men aged 20-34 and 50-74 and women aged above 49 years[15]. In
74 France a positive relationship between blood pressure and alcohol intake was more evident in
75 under 40 years[16]. A study in Japan found that the elevating effect of alcohol drinking on blood
76 pressure was more prominent in the elderly than in the young[17]. A study in Netherlands found

77 a stronger association between alcohol and blood pressure in older men compared with young
78 men[18]. A study in Michigan, USA found that alcohol intake patterns significantly changed the
79 relationship between age and blood pressure[19]. Such varying evidence calls for more localized
80 research that can inform local intervention. Africa has the lowest research output on most health
81 fields but more critically missing is evidence on Non-communicable diseases and their risk
82 factors in the local environment [20].

83 In 2016, 7% of women and 1% of men in age group 15-49 in Uganda were obese [21]. In 2014,
84 the National Non-Communicable Diseases (NCD) Risk Factor Survey found that the prevalence
85 of hypertension was 26.4% and it was associated with Body Mass Index (BMI) $> 25\text{kg/m}^2$ [6,
86 22]. These estimates are consistent with findings from other studies conducted in smaller
87 populations in Uganda which estimated the prevalence of hypertension to be in the range of
88 14%-35% [11]. On alcohol consumption the country is rated 5th highest consumer in Africa in
89 terms of per capita pure alcohol with an estimated average consumption of 9.8 liters (14.4 liters
90 for males and 5.2 liters for females) of pure alcohol per person per year[23].

91
92 There is a paucity of research on how alcohol affects obesity and hypertension levels across age
93 groups [24, 25] especially in developing countries yet this would inform age group specific
94 intervention. As such, the purpose of this study is to establish the trends of frequent alcohol
95 consumption, hypertension and obesity across different age groups and the extent to which the
96 frequency of alcohol consumption influences the trends of the two.

97

98

99 **Materials and Methods**

100 This paper uses secondary data from the National Non-Communicable Disease (NCD) Risk
101 Factor Survey of 2014. The survey included 3,987 participants aged 18-69 and 60% of them
102 were females. The data were collected using the STEPwise approach to surveillance (STEPS).
103 STEPS is a World Health Organization method that provides a standardized method for
104 collection, analysis and dissemination on risk factors for non-communicable diseases (NCD)[22].
105 The survey covered the whole country and used a three stage sampling design to select
106 participants. The first stage involved sampling enumeration areas (EA), followed by random
107 selection of 14 households in each EA and lastly a random selection of one member of household
108 from a list of eligible members. The response rate from the survey was 99% and more details on
109 the methods used can be obtained from the national NCD report or papers written from the
110 mother data set [6, 22].

111

112 For purposes of this study, only relevant variables were provided by the managers of the NCD
113 survey. Key among these variables were frequency of alcohol consumption and amount drunk in
114 previous 30 days, height, and weight, biometrics that include hypertension and body mass index,
115 socio-demographic-economic characteristics of the respondents.

116

117 Hypertension is defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90
118 mmHg [26] while obesity is defined as body mass index greater than 30 kg/m^2 [27].

119 Measurements for Systolic and diastolic blood pressure were taken three times and average for
120 each was computed. In the previous study the average was computed for only last 2

121 measurements and the difference is minor. Frequent alcohol consumption was measured as
122 taking alcohol 3 or more times a week.

123
124 We used log binomial regression to model hypertension and obesity with key independent
125 variable being age group and key interaction variable as frequency of alcohol consumption.
126 Binomial models were preferred because they provide prevalence ratios directly. Secondly unlike
127 the alternative logistic regression log binomial models do not overestimate their coefficients
128 when the outcome of interest is a common occurrence[28, 29] although they also have problems
129 of lack of convergence[19]. In the few times non-convergence occurred we used modified
130 Poisson regression which solves the problem but it is not also perfect since it produces
131 inconsistent variances[19]. Stata V14 software was used for analysis.

132
133 Log binomial models are expressed as follows[29]

134
135
$$p(y = 1 | x) = e^{x'\beta}$$

136 (1)

137 Where

138 p = Probability of occurrence of an event of interest in this study this is being
139 hypertensive or obese

140 y = Outcome of interest. This can be 1 (occurred) or 0 (did not occur)

141 x = Covariate

142 $x'\beta = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_nx_n$. This is the model's linear predictor where the
143 covariates can be continuous or dichotomous.

144

145 From the above the prevalence ratio is computed as an exponentiation of the product of the

146 coefficients and the difference in covariate values:

$$147 \quad \frac{p(y = 1 | x_1)}{p(y = 1 | x_0)} = e^{(x_1 - x_0)' \beta}$$

148 For a model with one dichotomous covariate the prevalence ratio is

$$149 \quad \frac{p(y = 1 | x = 1)}{p(y = 1 | x = 0)} = e^{\beta}$$

150

151 For modified Poisson regression

152 The following model is fitted but with robust variance estimators that will narrow the confidence

153 intervals of the estimates[30].

$$154 \quad g[E(y | \beta, x)] = \beta_0 + \beta_1 x_1 + \dots + \beta_p x_p$$

$$155 \quad \text{Where } P(y | \beta, x) = \frac{e^{-\beta} \beta^y}{y!}$$

$$156 \quad y = 1, 2, 3, \dots$$

157 g = Link function

158

159 Age was the main independent variable while alcohol consumption was the main modifying

160 factor under investigation. Charts were used to show trends of prevalence ratio for hypertension

161 and obesity across age groups and effect of alcohol consumption.

162

163 **Ethics**

164 The conduct of the National NCD Risk Factor Survey was approved by the Institutional Review
165 Committee of St. Francis Hospital Nsambya, Kampala, Uganda, and registered by the Uganda
166 National Council for Science and Technology. Written informed consent was obtained from
167 eligible subjects before enrollment in the study. Participants with an average systolic blood
168 pressure readings of at least 120 mm Hg, and/or diastolic blood pressure of at least 80mm Hg,
169 reporting not to be on treatment for hypertension, were advised to as soon as possible report to
170 the nearest government owned health facility for further evaluation. The Uganda ministry of
171 health granted permission to use the data for this work.

172

173 **Results**

174 **Characteristics of respondents**

175 A total of 2956(74.1%) of the respondents were in the age range 21-50 years. The age
176 distribution did not differ by sex (Table 1). Two thirds were married or in relationship, but
177 marital status varied by sex. Two fifths had attained primary school, but among women a higher
178 proportion did not have any formal education. Nearly two thirds were employed, but among
179 men a higher percentage were employed than among women (75% vs. 58%). The median income
180 per month was 100,000(≈USD 30) and it was significantly higher among men (110,000) (USD
181 ≈33) than women (60,000) (≈18).

182 The level of frequent alcohol consumption (3 or more times a week) was 8.4% but it was
183 significantly higher among men (16%) than women (3.4%). Obesity was at 7.5% and it was
184 higher among women (10.9%) than men (2.4%). Hypertension level was at 18.4% and it did not
185 significantly differ by sex.

186

187 **Table 1: Background Characteristics of the Respondents in NCD Survey**

Characteristics	Male's	Female's	All	Chi-sq. test
	N (%)	N (%)	N (%)	p-value
Age				
18-20	171(10.7)	257(10.8)	428(10.7)	
21-25	278 (17.3)	392 (16.5)	670 (16.8)	
26-30	261 (16.3)	412 (17.3)	673 (16.9)	
31-35	220 (13.7)	313 (13.1)	533 (13.4)	
36-40	194 (12.1)	267 (11.2)	461 (11.6)	NS-P>0.05

41-45	141 (8.8)	204 (8.6)	345 (8.7)	
46-50	97 (6.1)	177 (7.4)	274 (6.9)	
51-55	101 (6.3)	120 (5.0)	221 (5.5)	
56-60	63 (3.9)	96(4.0)	159 (4.0)	
61-65	48 (3.0)	92 (3.9)	140 (3.5)	
66-70	30 (1.9)	53 (2.2)	83 (2.1)	
Marital status				
Single	395 (24.6)	232(9.7)	627(15.7)	
Married/in relationship	1064(66.3)	1580(66.3)	2644(66.3)	
Widowed/other	145(9.1)	570(23.9)	715(17.9)	P<0.001
Education†				
None	123(7.7)	531(22.3)	654(16.4)	
Primary	643(40.1)	983(41.3)	1626(40.8)	
Secondary+	826(51.5)	865(36.3)	1691(42.4)	P<0.001
Work status				
Employed	1216(75.8)	1385(58.1)	2601(65.3)	
Student/unpaid worker	313(19.5)	832(34.9)	1145(28.7)	
Unemployed	75(4.7)	165(6.9)	240(6.0)	P<0.001
Income per month- median (IQR)	110,000(40,000- 300,000)	60,000 (20,000- 200,000)	100,000 (20,000- 200,000)	P<0.01
Drinks alcohol 3 times/more a week	252(15.7)	81(3.4)	333(8.4)	P<0.001
Obese (body mass index >30 kg/m²)	39(2.4)	259(10.9)	298(7.5)	P<0.001
Has hypertension (blood pressure-systolic ≥140mmHg or diastolic≥90)††	441(28.1)	604(25.9)	1045(26.8)	NS-P>0.05

189 *NB: all the above figures are unweighted*

190

191

192 **Alcohol consumption, hypertension and alcohol consumption across** 193 **different age groups**

194 Fig 1 shows the trend of frequent alcohol consumption, hypertension and obesity across age
195 groups. The levels of hypertension and frequent alcohol consumption rise with age group and
196 almost at the same average gradient until 46-50 years when the prevalence of hypertension rises
197 higher. The level of obesity reduces with age group to near zero in age group 51-55 when it rises,
198 but at a lower gradient. Values for all the three indicators start at nearly the same level and
199 sharply diverge after 26-30 year age group. A significant test of the gradient of each of the
200 trends in the figure below showed significance ($p < 0.01$).

201

202 ***Fig 1: Levels of hypertension, obesity and frequent alcohol consumption across different age***
203 ***groups***

204

205

206 **Effect of alcohol on the Hypertension- age relationship**

207 The prevalence ratios for hypertension rose by age group and this persisted after controlling for
208 frequency of alcohol consumption and other key factors (Table 2). A test of significance of an
209 interaction between frequency of alcohol consumption, hypertension and age group did not yield
210 any significance at 5% level but when age group was replaced with age in single years it was

211 significant. This shows that the relationship between alcohol consumption and hypertension
 212 significantly changed by single year rather than by age group.

213

214 **Table 2: Hypertension Prevalence ratios along different age groups and other factors**

215

Characteristics	Prevalence N (%)	Un-adjusted Prevalence ratio	Prevalence ratio adjusted for alcohol consumption
Age			
18-20	53(12.7)	1.0	1.0
21-25	119 (18.1)	1.43 (1.06-1.93)*	1.52 (1.12-2.06)**
26-30	139(21.1)	1.67 (1.25-2.23)**	1.84 (1.36-2.49)***
31-35	123(23.5)	1.86 (1.38-2.50) ***	2.10 (1.53-2.86)***
36-40	116(25.6)	2.02 (1.50-2.72) ***	2.27(1.66-3.12) ***
41-45	104(31.3)	2.48 (1.84-3.34) ***	2.80(2.03-3.85) ***
46-50	110(40.6)	3.21 (2.40-4.29) ***	3.65(2.67-4.99) ***
51-55	92(42.0)	3.32 (2.47-4.46) ***	3.76(2.73-5.17) ***
56-60	82(53.3)	4.21 (3.14-5.64) ***	4.71 (3.44-6.46) ***
61-65	64(46.0)	3.64 (2.67-4.96) ***	4.12 (2.94-5.77) ***
66-70	43(54.4)	4.30 (3.12-5.94) ***	4.76 (3.38-6.72) ***
Drinks alcohol 3 times/more a week			
3+ times weekly	104(32.0)	1	1
<3 times weekly	292(28.8)	0.90(0.75-1.08)	1.05 (0.88-1.26)

No/doesn't drink	649(25.3)	0.79 (0.67-0.94)**	1.01 (0.85-1.20)
Sex			
Male	441(28.0)	1	1
Female	604(25.9)	0.92 (0.83-1.02)	0.97 (0.87-1.08)
Marital status			
Single	128(20.9)	1.0	1
Married/in relationship	675(26.0)	1.25 (1.05-1.47)*	0.79 (0.66-0.95)*
Widowed/other	242 (34.8)	1.67 (1.39-2.01)***	0.82 (0.66-1.02)
Work status			
Employed	108(27.9)	1.0	--
Self employed	594(27.5)	0.98 (0.83-1.17)	--
Student/unpaid worker	270(24.1)	0.86 (0.71-1.04)	--
Unemployed	73(30.9)	1.11 (0.86-1.42)	--
Education†			
None	194(30.4)	1.0	--
Primary	429(26.8)	0.88(0.76-1.02)	--
Secondary+	316(24.6)	0.81(0.70-0.94)**	--
Tertiary	101 (27.9)	0.92(0.75-1.13)	--
Average Income per month			
<=500,000	252(27.1)	1	
>500,000	19(28.4)	1.05 (0.71-1.56)	--

216 †15 refused to provide information. -- left out because Wald test showed $p > 0.1$

217

218 Fig 2 shows the ratio of prevalence of hypertension at each age group to that at base age group of
219 18-20 by frequency of alcohol consumption. It's evident that after 40 years the hypertension
220 prevalence ratio across age groups among frequent drinkers was persistently lower than that
221 among those who did not take alcohol or drank moderately while trends for those who drank
222 moderately and those who never drank kept a steady rise at almost equal gradient. Beyond 60
223 years the ratio among the frequent drinkers dropped sharply to 0.8 rose slightly to 2.3.

224

225 **Fig 2: Prevalence ratios for Hypertension across age groups by frequency of alcohol**
226 **consumption among both men and women**

227

228 A closer examination of trends of prevalence ratios across age groups by sex showed that the
229 prevalence of hypertension across age groups is relatively lower among men that don't take
230 alcohol while it's the opposite among women (Fig 3). A Wilcoxon's rank sum test for the
231 difference was significant for men ($p=0.03$) but not for women ($p>0.1$). The figure left out those
232 who drank most frequently because they were too few to split by sex across age groups.

233

234 **Fig 3- Prevalence ratios for Hypertension across age groups by frequency of alcohol**
235 **consumption and by sex**

236

237 Fig 4 shows fitted lines for prevalence ratios for hypertension at different age groups by alcohol
238 consumption patterns. The figure complements results in Fig 2 and shows an interaction of
239 drinking pattern on hypertension-age group relationship which was not significant on use of age
240 group but significant on use of single year age.

241

242 **Fig 4: Fitted prevalence ratios for hypertension across different age groups by alcohol**

243 **consumption pattern**

244

245 A Wilcoxon's signed rank test of significance between the trends for drinking 3+days weekly &

246 <3 days weeks showed a significant difference ($p<0.001$). The same level of significance was

247 established with comparison of the trends for drinking 3+ weekly & No alcohol. Each of the

248 fitted lines had a statistically significant gradient.

249

250 **Obesity**

251 Fig 5 shows the trend of prevalence of obesity across all age groups. The prevalence of obesity

252 among women starts high up from around 18% in the age group 21-25 and declines to around

253 1% at the age group of 46-50 years while that among men starts low at 3.6% and reduces to 3.1%

254 in the same period. The test for the difference in the two trends using Wilcoxon's rank sum test

255 shows a p-value of $p=0.016$.

256

257

258

259 **Fig 5: Prevalence of obesity by sex across age groups**

260

261

262

263

264 Table 3 shows prevalent ratios for obesity. The prevalence ratios of obesity reduced with
 265 increasing age groups even after controlling for drinking patterns and marital status which were
 266 significant in the bivariate analysis. A test of interaction with frequency of alcohol consumption
 267 did not show any significance hence lack of influence on the obesity-age group relationship.

268 **Table 3: Obesity Prevalence ratios in different age groups and other factors**

269

Characteristics	Prevalence N (%)	Un-adjusted Prevalence ratio	Prevalence ratio adjusted for alcohol consumption
Age			
18-20	39 (9.1)	1.00	1.0
21-25	79 (11.8)	1.29 (0.90-1.86)	1.05 (0.74-1.51)
26-30	76 (11.3)	1.24 (0.86-1.79)	0.91 (0.63-1.32)
31-35	40(7.5)	0.82 (0.54-1.26)	0.61 (0.40-0.78)**
36-40	26 (5.6)	0.62 (0.38-1.00)*	0.47 (0.29-0.76)***
41-45	17 (4.9)	0.54 (0.31-0.94)*	0.40 (0.23-0.69) ***
46-50	5 (1.8)	0.20 (0.08-0.50)**	0.14 (0.06-0.36) ***
51-55	2 (0.9)	0.10 (0.02-0.41)**	0.08 (0.02-0.33) ***
56-60	5(3.14)	0.35 (0.14-0.86)*	0.27 (0.11-0.68)**
61-65	4 (2.9)	0.31 (0.11-0.86)*	0.23 (0.08-0.65)**
66-70	5 (6.0)	0.66 (0.27-1.63)	0.41 (0.15-1.14)
Sex			
Male	39(2.4)	1	1
Female	256 (10.9)	4.47 (3.21-6.22)***	4.23 (3.00-5.97)***

Drinks alcohol 3

times/more a week

3+ times weekly	16(4.8)	1	1.00
<3 times weekly	72 (6.9)	1.44 (0.85-2.74)	0.74 (0.44-1.23)
No/doesn't drink	210 (8.0)	1.67 (1.02-2.74)*	0.69 (0.42-1.13)

Marital status

Single	25 (4.0)	1	1.00
Married/in relationship	235 (8.9)	2.23 (1.49-3.34)***	2.41 (1.58-3.68)***
Widowed/other	37 (5.2)	1.30 (0.79-2.13)	1.71 (1.00-2.91)*

Work status

Employed	29 (7.2)	1	
Self employed	147 (6.7)	0.93 (0.63-1.36)	--
Student/unpaid worker	106(9.3)	1.29 (0.87-1.91)	--
Unemployed	15 (6.2)	0.87 (0.48-1.59)	--

Education†

None	41 (6.3)	1.00	--
Primary	127 (7.8)	1.25 (0.89-1.75)	--
Secondary+	106 (8.1)	1.28 (0.91-1.82)	--
Tertiary	22 (5.9)	0.94 (0.57-1.55)	--
Refused	1 (6.7)	1.07 (0.15-7.22)	--

Average Income per

month

<=500,000	75 (7.8)	1.00	--
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>500,000	3 (4.4)	0.56 (0.18-1.72)	--
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270 †15 refused to provide information.

271 NB: interaction terms for alcohol consumption on hypertension-AGE relationship were not significant even after running the
272 models by sex

273

274 Fig 6 shows the trend for obesity levels over age groups by frequency of alcohol consumption.

275 The chart confirms results from table 3. There is a general declining trend of obesity across the
276 age groups and it did not significantly vary by frequency of alcohol consumption.

277

278 **Fig 6: Prevalence ratios for obesity across age groups by frequency of alcohol consumption**

279

280

281

282 **Discussion**

283 This study explored relationship patterns of alcohol with hypertension and obesity across
284 different age groups. The findings show that the prevalence of frequent alcohol consumption and
285 hypertension follow a nearly similar increasing trend across all age groups below 50 years while
286 the prevalence for obesity follows a downward trend. The relationship between frequent alcohol
287 consumption and hypertension is significant and it changes significantly by age in single years
288 but not by 5 year age groups. The relationship between frequent alcohol consumption and
289 obesity is not significant and does not change across different age groups. Across all age groups
290 the prevalence of hypertension among frequent drinkers is lower than those who either don't
291 drink or drink less. While among men it's the non-drinkers that have low prevalence of
292 hypertension it's the opposite among women.

293 The increasing trends of frequent alcohol consumption and hypertension across age groups are
294 consistent with several studies in different parts of the world [31] but inconsistent with studies in
295 some other communities[32]. The increasing trend for alcohol consumption can be explained by
296 increased access and ability to buy alcohol which may reduce after 50 years due to change in
297 lifestyle, working environment and social network. Another view could be threshold effect where
298 frequent alcohol consumption exacerbates physiological damages that may also lead to
299 hypertension. However, we noticed that among those who used alcohol frequently, the
300 prevalence ratios rose sharply, dropped and rose again. Future research may examine this pattern
301 more specifically and address other contextual factors not addressed in this study including
302 potential cohort effects, age since alcohol initiation and other potential factors that can impact
303 these findings.

304 The strong relationship between frequent alcohol consumption and hypertension is reported in
305 many studies [33] and some affirm a causal relationship[34]. However, the change in this
306 relationship with single years and not 5 year age groups is what needs to be investigated further.
307 The prevalence of obesity reduces with age groups but this is more evident among women where
308 it declines sharply between age groups 21-25 and 46-50. This contrasts with studies that show
309 increasing trend of obesity with age group among women in other countries [35, 36] but others
310 show decline with age[37, 38]. While some studies have found a significant positive relationship
311 between alcohol consumption and obesity[39] this study did not find such relationship
312 significant. The negative association between age and obesity can be partially explained by the
313 lower life expectancy observed in Uganda compared to populations examined elsewhere as well
314 as a potential cohort effect of the older participants in this study.
315 Lower prevalence of hypertension among frequent alcohol consumers compared to the abstainers
316 and infrequent drinkers is an issue that needs further investigation. One probable explanation is
317 the low number of respondents that were frequent alcohol consumers. In subsequent analysis by
318 sex the frequent consumers were left out because of small numbers.

319 **Conclusion**

320 We conclude, firstly, that the prevalence of frequent alcohol consumption increases across the
321 age groups at almost the same level with prevalence of hypertension until 50 years of age.
322 The frequency of alcohol consumption did not significantly modify the age group-hypertension
323 and obesity-age group relationships but the effect was significant with single years.
324 The prevalence of hypertension among frequent alcohol consumers is lower than that among
325 abstainers and infrequent/mild drinkers. This calls for further research as this is inconsistent with
326 several studies.

327 While among men it's the non-drinkers that have lower prevalence of hypertension than the mild
328 drinkers across age groups it's the opposite among women although the difference is not
329 significant as in the case with the men. More research is needed to identify causes behind this
330 difference.

331 Programs aimed at reducing hypertension should include messages on abstinence from alcohol
332 consumption especially among men. Priority should also go to older persons.

333 Frequent alcohol consumption is a key factor in the prevalence of hypertension among most age
334 groups examined, but particularly among those ages 40 and above. Frequent drinking is a
335 modifiable factor that needs to be addressed within clinical practice. Typically, while treatment
336 protocols may include counseling patients on the risk of alcohol, it is not clear whether doctors
337 or health care providers in Uganda have fully embraced or implemented alcohol reduction
338 strategies such as alcohol screening and brief interventions in their treatment of hypertension (is
339 this true). However, this modification to current clinical practice should be explored and
340 investigated further. Moreover, additional research is needed to determine the biological
341 mechanism linking alcohol use to hypertension and what factors exacerbate this association
342 among adults in their 40-50s.

343 These findings underscore the importance of examining alcohol use in the context of non-
344 communicable diseases in order to determine prevention and intervention strategies.

345 **Limitations**

346 Our findings should be considered in the context of several limitations. First and foremost, the
347 data are self-reported and as such, inherent biases or lack of knowledge about certain health
348 conditions may have yielded an underestimate of both obesity and hypertension. Moreover,
349 while disclosing alcohol use is not considered a sensitive matter, study participants across

350 settings often under report actual use. Most likely these limitations yield an underestimate of the
351 true association between alcohol use, hypertension and obesity than what has been reported in
352 this study. Moreover, the analyses were based on a cross sectional survey and as such we could
353 not measure the timing and prospective association of the associations between alcohol use and
354 hypertension and obesity which would be of great importance for future prospective cohort
355 studies. Finally, we included several potential confounders in our analyses. However, there may
356 be other important variables that were not considered or available for analyses.

357 **Ethics**

358 The principal investigator obtained a written permission to use the secondary data from the
359 management of the non-communicable diseases risk factor survey of 2014.

360 **Acknowledgement**

361 We thank the investigators and sponsors of the Uganda National Study of Non-Communicable
362 Diseases risk factor survey of 2014. We further thank all staff and participants in the study
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365

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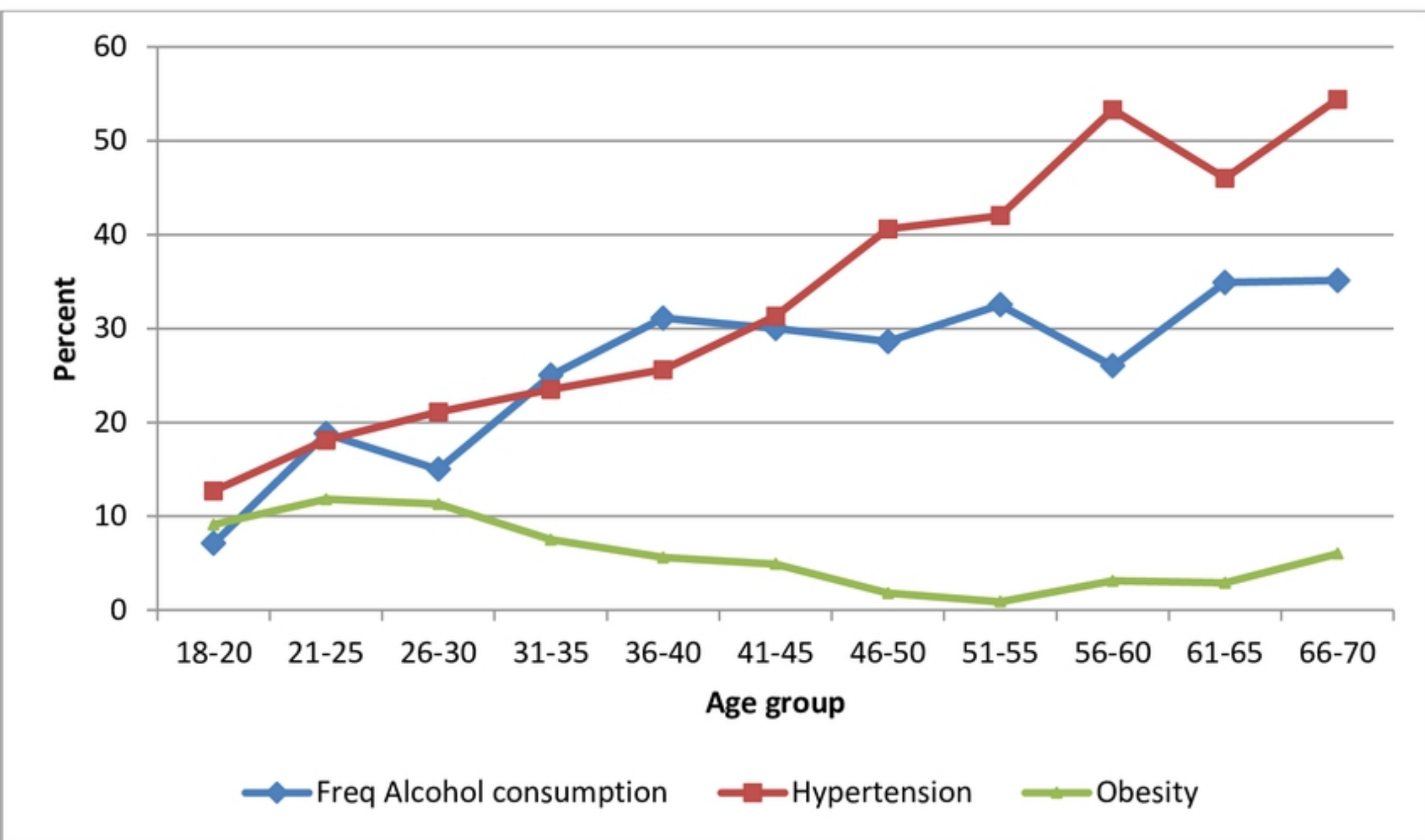
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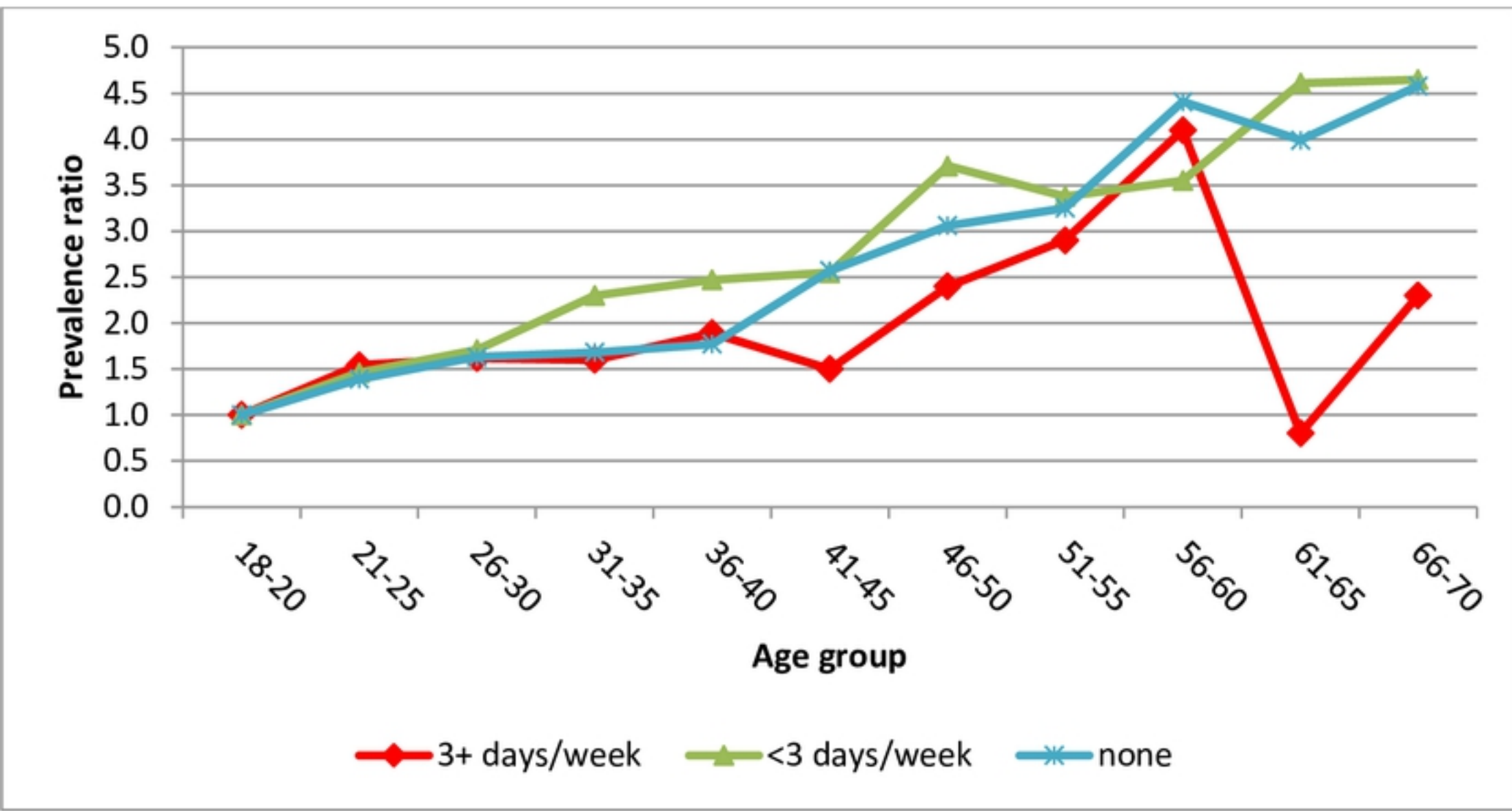
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474

Figure 1: Levels of hypertension, obesity and frequent alcohol consumption across different age groups



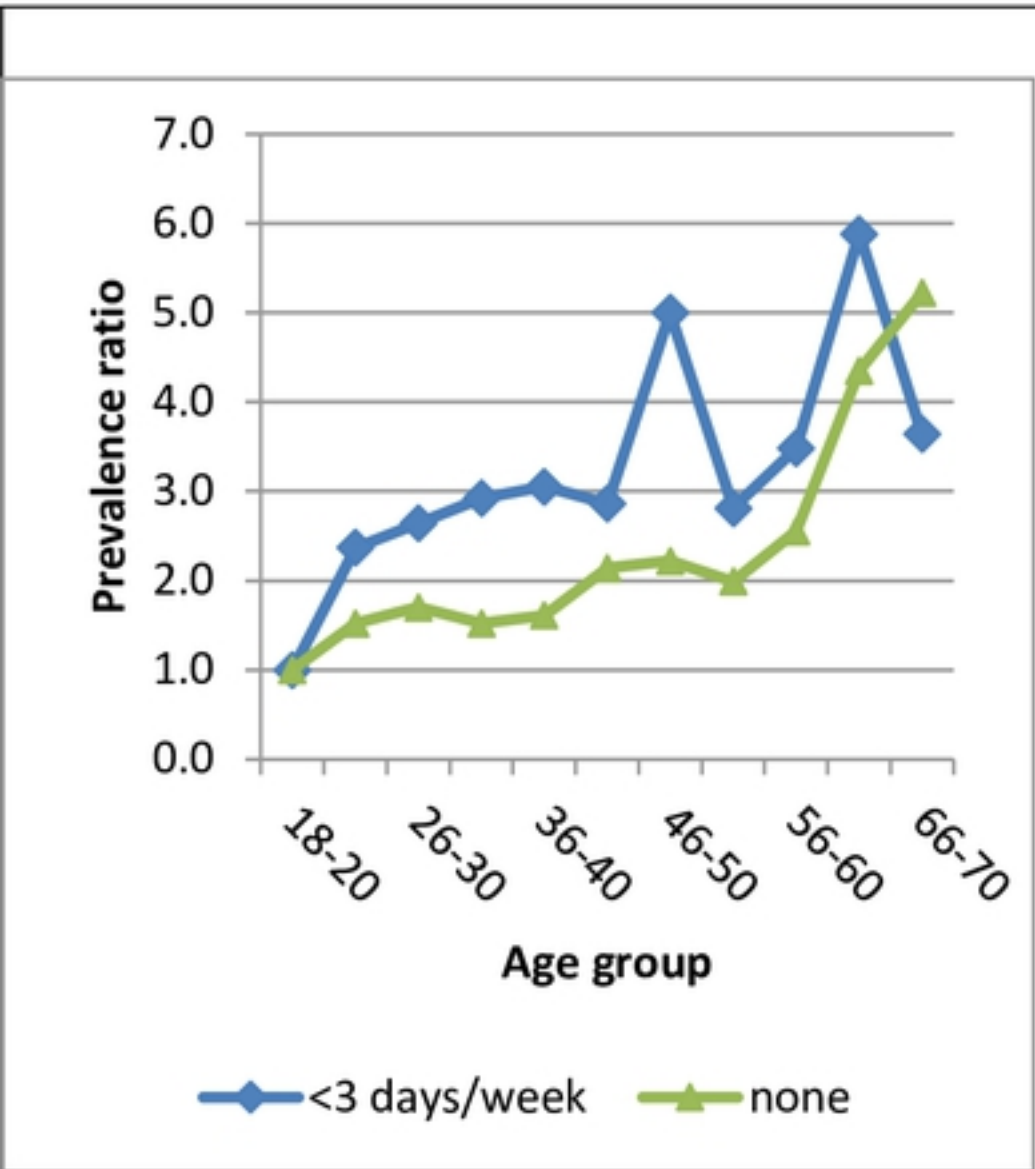
Figure

Figure 2: Prevalence ratios for Hypertension across age groups by frequency of alcohol consumption among both men and women

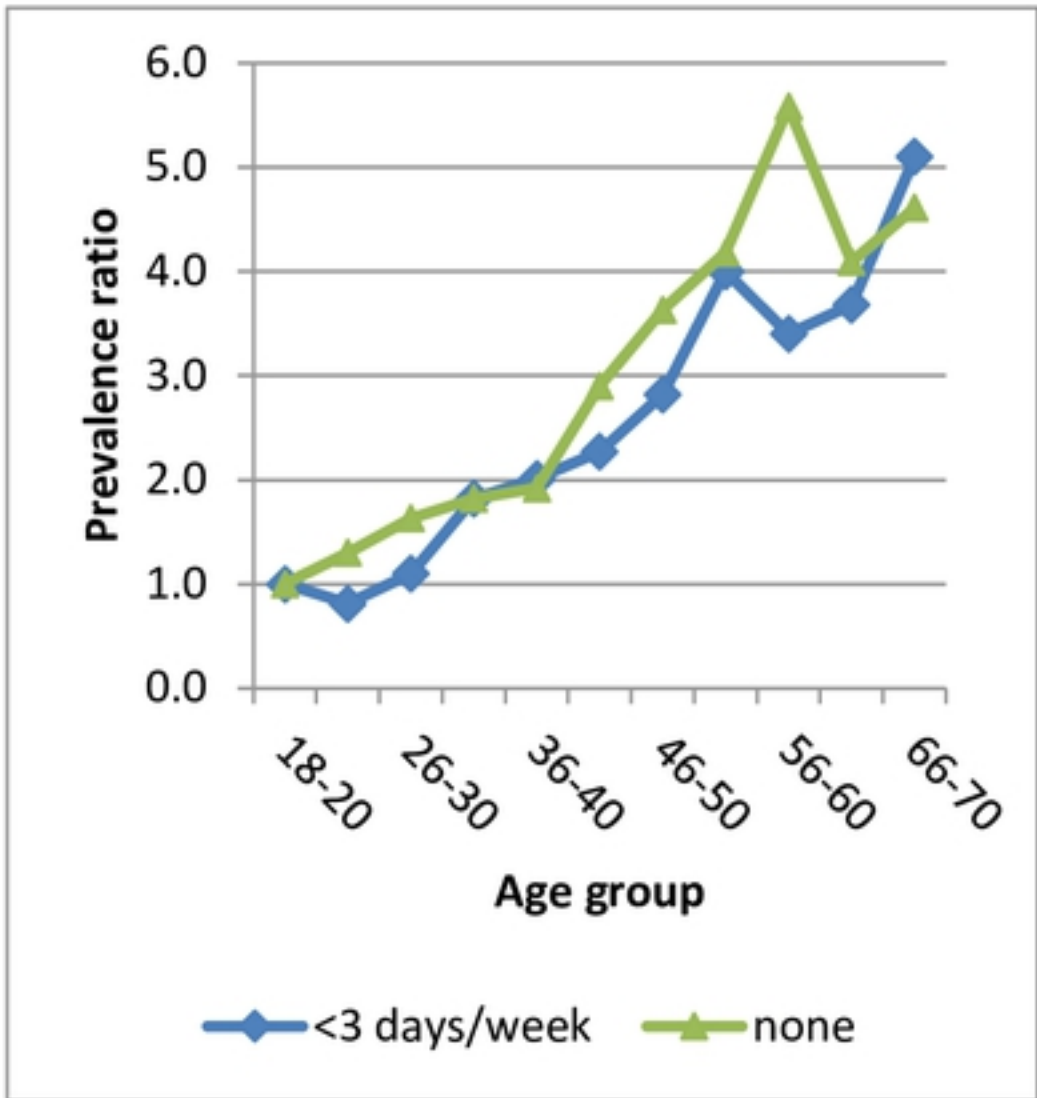


Figure

Figure 3: Prevalence ratios for Hypertension across age groups by frequency of alcohol consumption and by sex



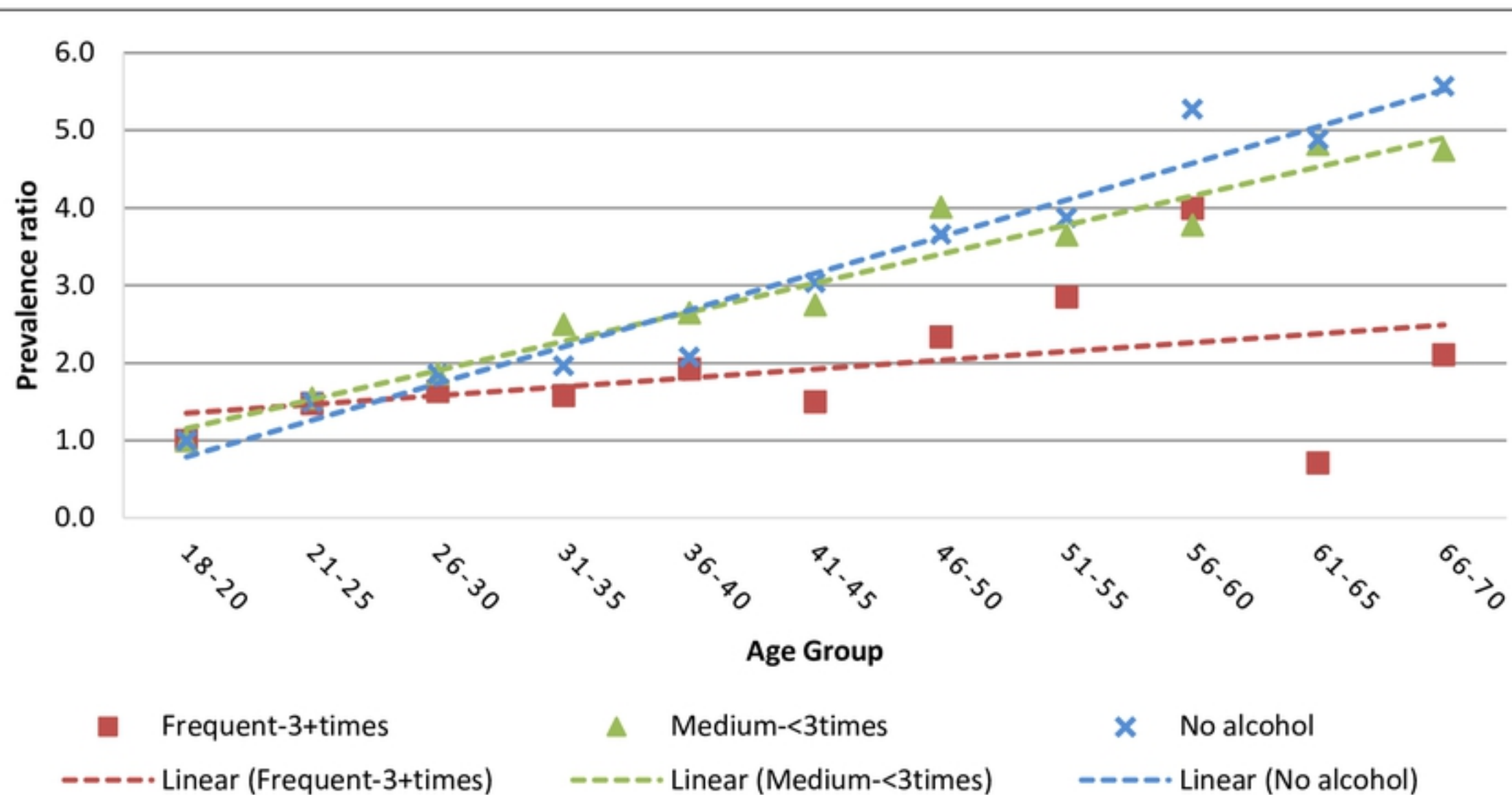
Men



Women

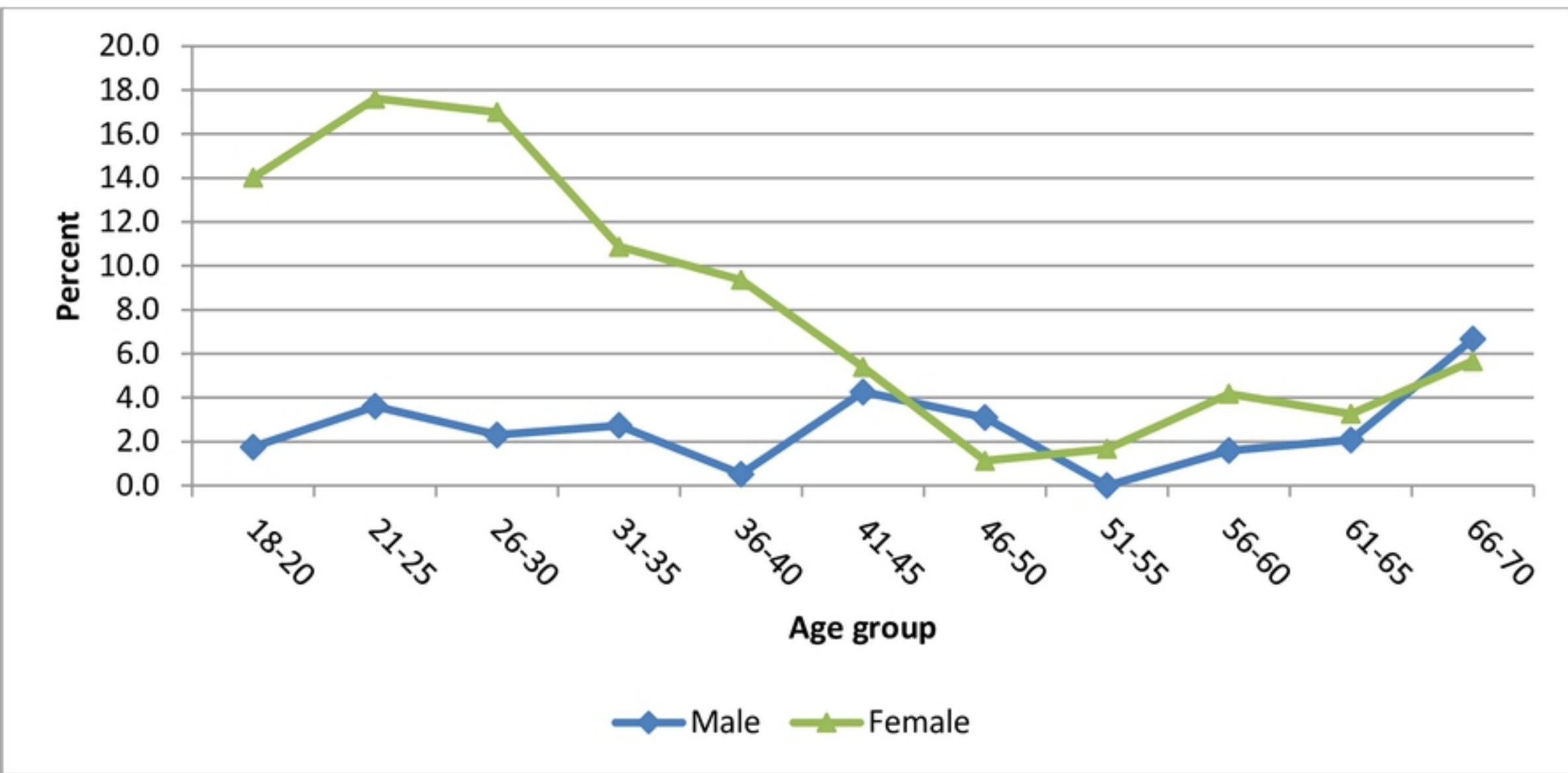
Figure

Figure 4: Fitted Prevalence ratios for hypertension across different age groups by alcohol consumption pattern



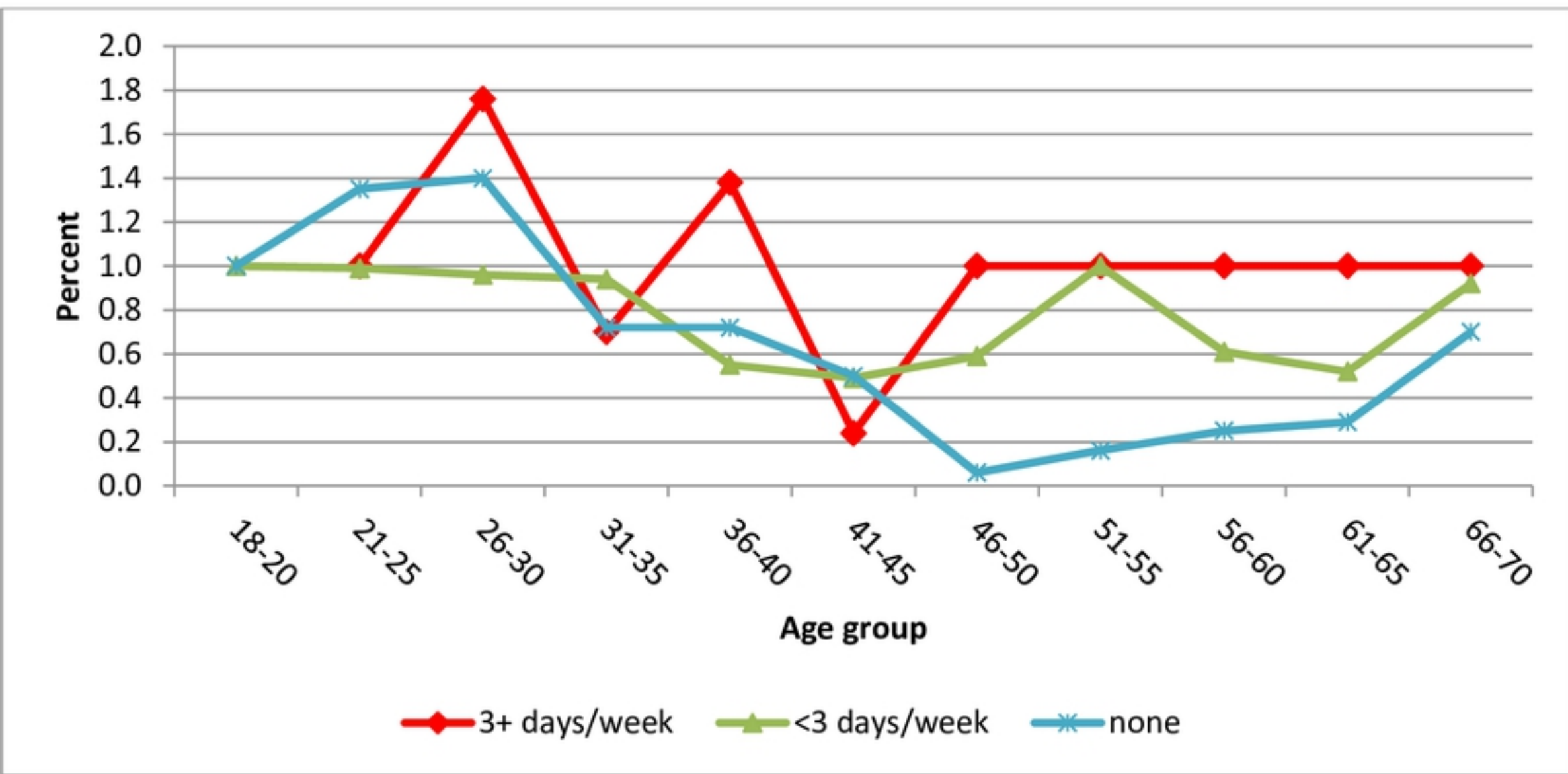
Figure

Figure 5: Prevalence of obesity by sex across age groups



Figure

Figure 6: Prevalence ratios for obesity across age groups by frequency of alcohol consumption



Figure