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Residential environments, alcohol advertising, and initiation and continuation of alcohol consumption among adolescents in urban Taiwan: A prospective multilevel study

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ABSTRACT

Background: Research indicates that place characteristics and the media environment are important contextual determinants of underage drinking behaviors in Western countries, but it is unknown whether these exposures influence adolescent alcohol consumption outside Western contexts, including in Asia's emerging global alcohol markets. Guided by the social ecological framework, we prospectively investigated the influences of place characteristics and alcohol advertising on initiation and continuation of alcohol consumption among adolescents in Taipei, Taiwan.

Methods: Data on individual-level characteristics, including alcohol use behaviors and perceived exposure to alcohol advertising, were obtained from two waves of a longitudinal school-based study through a stratified probability sampling method in 2010 (Grade 7/Grade 8, aged 13–14 years old) and 2011–2012 (Grade 9, aged 15 years old) from 1795 adolescents residing in 22 of 41 districts in Taipei. Data on district-level characteristics were drawn from administrative sources and Google Street View virtual audit to describe districts where adolescents lived at baseline. Hierarchical generalized linear models tested hypotheses about the associations of place characteristics and perceived alcohol advertising with underage drinking, with stratification by baseline lifetime alcohol consumption.

Results: Among alcohol-naïve adolescents, lower district-level economic disadvantage, a higher proportion of betel nut kiosks (a relatively unregulated alcohol source) compared to off-premises alcohol outlets, and exposure to television-based alcohol advertising predicted increased likelihood of alcohol initiation at one-year follow-up. Among alcohol-experienced adolescents, greater spatial access to off-premises alcohol outlets, and lower access to metro rapid transportation (MRT) and to temples were found to predict a subsequent increased likelihood of continued alcohol use. Parental drinking moderated the relationship between district-level violent crime and initiation of alcohol consumption.

Conclusions: These findings suggest that local social economic status, alcohol access, and institutional resource and individual media exposure affect underage drinking behaviors in Taiwan. We discuss potential public health implications for place-based interventions. Future research on place, media, and adolescent alcohol consumption in Asian contexts is warranted.

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1. Introduction

Alcohol industry has been expanding into emerging markets in Asia, Africa, and Latin America, and recent research suggests that this expansion has had alarming effects on youth (Jernigan &

Rushman, 2014; World Health Organization Regional Office for the Western Pacific, 2015). For example, Taiwan opened its alcohol market to international alcohol industries in 1987. Since then, new alcoholic products have been introduced to the Taiwanese market and alcohol industries have launched various marketing approaches to reach younger population (Euromonitor International, 2014). Recent national surveys in Taiwan indicated the percentage of lifetime alcohol consumption among middle school students increased ten percentage points in just 4 years, from 55% in 2006 to 65% in 2010 (Health Promotion Administration, 2010). The

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incidence rate of alcohol consumption among middle school students also increased from 14% in 2004 to 18% in 2005 (Chen et al., 2009). The combination of rapidly expanding global alcohol marketing combined with the increasing prevalence of underage alcohol use underscores the urgent need to investigate multilevel contexts to underage drinking in emerging alcohol markets (World Health Organization Regional Office for the Western Pacific, 2015).

According to the World Health Organization (WHO), alcohol use is the greatest contributor to disability and mortality among individuals aged 10–24 years globally (Gore et al., 2011; Rehm, Taylor, & Room, 2006). Early initiation of alcohol use increases the risks of a variety of problematic behaviors, both in the short- (e.g., school dropout, delinquent behaviors) and long-term (e.g., subsequent problem drinking, other substance use) (Windle et al., 2009; Zucker, Donovan, Masten, Mattson, & Moss, 2009). Adolescence, the period when alcohol initiation escalates, is a transitional developmental stage characterized by changes in, and increased exposure to, social contexts outside the home (Cook, Herman, Phillips, & Settersten, 2002). According to the social ecological framework of human development (Bronfenbrenner, 1979), adolescent behaviors, including alcohol consumption, are greatly affected by influences operating at multiple layers of the social context, including place-based social and built environments and the media environment (Anderson, de Bruijn, Angus, Gordon, & Hastings, 2009; Bryden, Roberts, McKee, & Petticrew, 2012; Bryden, Roberts, Petticrew, & McKee, 2013; Jackson, Denny, & Ameratunga, 2014).

Prior research investigating the effects of multiple layers of context on underage drinking has primarily been conducted in the West (Bryden et al., 2012, 2013). Because of the rapid expansion of global alcohol marketing in Asia, Taiwanese society has experienced large increases in alcohol availability and alcohol marketing (Euromonitor International, 2014; World Health Organization Regional Office for the Western Pacific, 2015). For example, the price of alcoholic beverages has decreased and global alcohol companies (e.g., Heineken, SABMiller) have gradually gained a greater share of the domestic market (Euromonitor International, 2014). Guided by the social ecological framework, this study investigates whether place-based environments and media environments affect adolescent alcohol initiation and continuation in Taipei, Taiwan. We focus on three types of place-based environments that are important to underage drinking behaviors: social, alcohol access, and institutional resource environments.

1.1. Place-based social environments

Social Disorganization Theory posits that place-based social disadvantage (e.g., economic disadvantage, violent crime) is associated with diminished social integration resulting in increased problem behaviors (Shaw & McKay, 1942). Recent systematic reviews revealed that findings about associations between place-based economic disadvantage and underage drinking are mixed (Bryden et al., 2012; Jackson et al., 2014; Karriker-Jaffe, 2011). Some cross-sectional studies found that economic disadvantage was associated with higher levels of underage drinking (Bernburg, Thorlindsson, & Sigfusdottir, 2009; De Haan, Boljevac, & Schaefer, 2010; Huckle, Huakau, Sweetsur, Huisman, & Casswell, 2008), while others indicated that local affluence was positively associated with this outcome (Lo, Anderson, Minugh, & Lomuto, 2006; Reboussin, Preisser, Song, & Wolfson, 2010; Snedker, Herting, & Walton, 2009). Still other studies have found no association between economic disadvantage and underage drinking (Brenner, Bauermeister, & Zimmerman, 2011; Fagan, Wright, & Pinchevsky, 2013; Kulis, Marsiglia, Sicotte, & Nieri, 2007). The mixed findings may arise from using different measures of place-based economic disadvantage; the lack of longitudinal studies may also prevent place-based research from providing consistent and rigorous evidence. As to the connection between place-based violent crime and underage drinking, the results are more consistent than that of economic

disadvantage. Studies have generally found a positive association between place-based violent crime and underage drinking (Lambert, Brown, Phillips, & Jalongo, 2004; Yabiku, Dixon Rayle, Okamoto, Marsiglia, & Kulis, 2007). However, studies of relationships between these place-based environments and underage drinking have rarely been conducted in emerging alcohol market in Asia, where social relationships, resident composition, and collective interaction are profoundly different from those of Western contexts. For example, in Taipei, the mixed land use of commercial and residential zones, efficient public transportation, relatively short distance between activity locations, and the strong social value of collective power often encourage social interaction and local bonds for residents. It is unknown whether these place-based social environments affect underage drinking in Asian countries.

1.2. Place-based alcohol access environments

Research on the alcohol access environment, however, has been unequivocal: recent systematic reviews have suggested that the alcohol access environment is a powerful place-based risk factor for drinking behaviors, especially for adolescents (Bryden et al., 2012; Popova, Giesbrecht, Bekmuradov, & Patra, 2009). A positive association between alcohol outlet density and underage drinking has been found in both cross-sectional and longitudinal studies in several Western societies, including in the United States (Chen, Grube, & Gruenewald, 2010; Paschall, Lipperman-Kreda, & Grube, 2014), Australia (Azar et al., 2016; Livingston, Laslett, & Dietze, 2008; Rowland et al., 2014, 2016), New Zealand (Huckle et al., 2008), and Switzerland (Kuntsche, Kenedig, & Gmel, 2008). According to Availability Theory, increased proximity to alcohol outlets creates an “alco-genic” environment that not only increases alcohol access but also establishes pro-alcohol norms, both of which in turn increase the risk of underage drinking (Livingston, Chikritzhs, & Room, 2007). To date, only few studies have examined the impact of alcohol outlets on underage drinking in Taiwan (Chen et al., 2011; Wang et al., 2013), and none has adopted a longitudinal design to examine this relationship.

Betel nut kiosks, the local unregulated off-premises alcohol outlets in Taiwan, are one of major commercial alcohol sources; they are pervasive on thoroughfares in urban Taiwanese areas. Owners of betel nut kiosks often hire “betel nut beauties”, young women who dress in “provocative” clothing to sell betel nuts, soft drinks, and beer. Local news has reported that these unregulated alcohol outlets are one of the easiest commercial sources of alcohol access for adolescents, and the number of betel nut kiosks can exceed that of ordinary off-premises alcohol outlets (e.g., convenience stores). Betel nut kiosks are a unique feature of Taiwanese culture, and it is unknown whether spatial access to betel nut kiosks can influence underage drinking. While the impact of the ordinary off-premises alcohol outlets (e.g., convenience stores) has been studied (Chen et al., 2011; Wang et al., 2013), little attention has been paid to this unique type of off-premises alcohol outlet, perhaps because of the lack of available data on betel nut kiosks.

1.3. Place-based institutional resource environments

Prosocial institutional resources (e.g., recreational open spaces, schools, and religious resources) influence adolescent development and can shape adolescent behaviors (Leventhal & Brooks-Gunn, 2000). To date, however, studies examining the effects of protective environmental features for adolescent alcohol consumption are limited. One recent cross-sectional study conducted in rural and small towns in the United States found that spatial access to youth-serving organizations was inversely associated with adolescent lifetime alcohol use (Chilenski, 2011). Similarly, a cross-sectional study conducted in Taiwan found that greater spatial access to colleges in neighborhood was associated with

lower likelihood of purchasing alcohol among children (Chen et al., 2011). Evidence on prospective effects of prosocial institutional resources on underage drinking is generally lacking.

1.4. Interactions between place-based environments and individual-level risk factors

Recent studies of underage drinking not only investigate the independent effects of place-based environments, but also explore whether the relationships of place-based environments to underage drinking behaviors differ by individual characteristics (Mrug, Gaines, Su, & Windle, 2010; Snedker et al., 2009; Trim & Chassin, 2008). Some individual characteristics such as poor parenting practices and lower individual economic strain may amplify the adverse effects of specific place-based environments (De Haan et al., 2010; Mrug et al., 2010), while other individual characteristics such as religious attendance and family support may have buffering effects (Lo et al., 2006; Snedker & Herting, 2008). For example, Trim and Chassin (2008) found that the prospective effect of economic disadvantage operated differently across subgroups: higher place-based economic disadvantage increased the rate of alcohol use among adolescents whose parents were alcoholics, while lower economic disadvantage increased the rate of alcohol use among adolescents whose parents were not alcoholics.

1.5. Media environment of alcohol advertising

Media is an influential environment through which adolescents form attitudes and expectations about alcohol and its effects (Zucker et al., 2009). Two recent reviews indicate that alcohol advertising contributed to alcohol initiation and higher levels of use among those with prior use (Anderson et al., 2009; Smith & Foxcroft, 2009). Social Cognitive Theory suggests that human behaviors can be affected by environmental influences through observational learning and social reinforcement (Bandura, 2004). Using both perceived (e.g., self-reported) and objective (e.g., auditor-observed) measures, previous studies have assessed the impacts of alcohol advertising through several media channels such as televisions, movies, magazines, and websites (Pasch, Komro, Perry, Hearst, & Farbaksh, 2007; Unger, Schuster, Zogg, Dent, & Stacy, 2003). Among these media channels, television is a particularly influential media channel through which adolescents obtain information about alcoholic beverages, and perceived exposure to television commercials increases the risks of subsequent alcohol use (Fisher, Miles, Austin, Camargo, & Colditz, 2007; Stacy, Zogg, Unger, & Dent, 2004). In Taiwan, adolescents reported spending 15.4 hours per week watching television (Wu, 2009). Although alcohol advertising on television is banned during children's viewing time from 6:00 am to 9:00 pm, only 27.5% of parents limit their children's television watching time (Wu, 2009). Public health research on media environments and alcohol use has failed to keep up with the rapid expansion of global alcohol marketing into emerging markets outside of Western countries (Casswell, 2012; Jernigan, 2010). To date, research that examines the impact of alcohol advertising on underage drinking in emerging alcohol markets has been limited (Chang et al., 2014).

1.6. Hypotheses

Based on the existing evidence and theories, we hypothesized that greater exposure to place-based economic disadvantage and violent crime, and greater alcohol access at baseline, would be prospectively associated with an increased likelihood of alcohol initiation and continuation among Taiwanese adolescents, while greater exposure to place-based institutional resources would prospectively reduce these outcomes. Furthermore, greater exposure to alcohol advertising at

baseline would be associated with subsequent increased likelihood of adolescent alcohol initiation and continuation.

We tested several cross-level interactions. We hypothesized that individual-level family drinking behaviors (i.e., parental drinking and parental approval to drink) and peer drinking behaviors would exacerbate negative effects of place-based economic disadvantage and violent crime on alcohol use among adolescents.

2. Materials and methods

2.1. Study sample

The data for the present study were from two waves of the Alcohol-Related Experiences among Children (AREC) II study, a longitudinal school-based study designed to investigate determinants of alcohol-related experiences from early adolescence to young adulthood in Taipei, Taiwan. AREC II methods have been described in detail elsewhere (Lee et al., 2015). In brief, a stratified probability sampling was used to select 16 public middle schools in Taipei based on school characteristics (e.g., student-teacher ratio) and the physical environment surrounding the schools (e.g., public transportation density) to obtain representative sample of middle school students in Taipei. It should be noted that the sample does not represent students living in the total Taipei Metropolitan Area due to this school-based sampling scheme (i.e., the stratification was based on schools instead of districts). With active parent and student consent, baseline data were collected from 1926 adolescents in 2010 (students were in Grade 7 in spring semester and Grade 8 during the fall semester, aged 13–14 years old); 1893 of these adolescents participated in the Grade 9 (aged 15 years old) follow up survey. The mean interval between the two assessment waves was 13 months. The overall participation rate at baseline was 55% and the follow-up rate was 98%. A total of 1870 respondents completed both waves of the surveys.

Study procedures were approved by the National Health Research Institutes in Taiwan and Emory University's Institutional Review Board.

2.2. Measures

We used a repeated measurement study design for the current study. All predictors (i.e., district-level characteristics and the perceived exposure to alcohol advertising) and individual covariates were measured at baseline; the outcome measured alcohol use behavior change between baseline and follow-up.

2.2.1. Outcomes

Initiation of alcohol use was assessed by examining responses to two items: "Not including a sip of alcohol and alcoholic beverages added in meals, have you ever drunk alcohol in your life?" [Responses: no=0 and yes=1], and a wave II item querying alcohol consumption in the past 12 months. Those who transitioned from "never used (i.e., alcohol-naïve adolescents)" to "used" alcohol across two waves were labeled initiators.

Continuation of alcohol use was defined as alcohol use both at baseline (i.e., alcohol-experienced adolescents) and at Wave II (yes) versus use only at baseline.

2.2.2. District-level predictors

2.2.2.1. Geographical area. The geographical unit of analysis in the current study is the district (*chu*). These administrative districts are created based on natural boundaries and economic development. The median district population was 208,430 and the median square kilometers was 21.8 (8.4 square miles).

At the baseline, AREC II asked what district respondents lived in, covering a total of 29 districts of Taipei metropolitan area.

2.2.2.2. Social environments

2.2.2.2.1. Economic disadvantage. Economic disadvantage was measured using four indicators in 2010: (1) the percentages of residents aged 25–44 without a high school diploma; (2) the annual median household income; (3) the percentages of vacant homes built before 2006; and (4) the percentages of residents who were ethnic minorities. These economic indicators were obtained from several administrative sources, including the Taiwan Census, Ministry of Interior, and Ministry of Finance. Due to the high degree of correlation among these four indicators, we constructed the district economic disadvantage index using principal component analysis (PCA). Cronbach's alpha for the economic disadvantage index was 0.86, and the index accounted for 70.7% of the variation from the PCA. A higher value of the index denotes greater district-level economic disadvantages.

2.2.2.2.2. Violent crime rate. The violent crime rate was defined as the density of violent crime incidents reported per 100,000 residents in 2010. Violent crime includes murder, kidnapping, robbery, aggravated assault, forcible rape, and serious extortion threat. Annual data on the number of violent crime reported were obtained from the Taipei City Police Department and the New Taipei City Police Department.

2.2.2.3. Alcohol access environments. Three types of alcohol outlets were assessed: on-premises consumption outlets (i.e., all-you-can-eat barbeque restaurants and karaokes), off-premises consumption outlets (i.e., convenience stores, grocery stores, and warehouse clubs), and betel nut kiosks.

Alcohol access was measured as the number of alcohol outlets per square kilometers within each district. Annual data on the numbers of on- and off-premises consumption outlets in 2010 were obtained from UrMap, an online map with geocoding data that can be used for navigation in Taiwan and has been demonstrated as a high quality data system providing location-based services for several types of Points-Of-Interests (POIs) (Chang & Tsou, 2008; OleMap, 2010).

2.2.2.3.1. Google Street View virtual audit. Given the lack of administrative data on the locations of betel nut kiosks, we created this measure by conducting a virtual audit of Google Street View data. The audit was conducted by two trained auditors using historical Google Street View images from 2009 (about one year before the baseline). The two auditors conducted virtual audits along both sides of each thoroughfare in the studied districts using standardized procedures. Districts with less than 5 participants lived in were excluded from the virtual audits because of the time constrain ($n=7$). Information on the geo-coordinates, names, addresses, operation status, images, and month and year of the images of the observed betel nut kiosks was recorded. Random subsets of the thoroughfares were double coded with 91% observed agreement. Spatial access to betel nut kiosks was measured as the ratio of the number of betel nut kiosks to the number of off-premises alcohol outlets. Based on Diez-Roux and Mair's (2010) recommendation to measure relevant spatial contexts, we used a ratio measure for kiosks (instead of a density measure) because focus group data indicated that adolescents consider the *relative proximity* of betel nut kiosks to off-premises alcohol outlets as an important factor when deciding whether to purchase alcohol from a betel nut kiosk (Chen et al., unpublished data). That is, focus group members reported that adolescents would purchase alcoholic beverages from betel nut kiosks when these kiosks were closer than regular off-premises alcohol outlets (e.g., convenience stores). Therefore, a ratio measure was constructed.

2.2.2.4. Institutional resource environments. We measured the number of each of three types of institutional resources per square kilometers for each district: (1) Taipei Metro Rapid Transit (MRT) exits; (2) recreational resources (i.e., parks and physical activity centers); and (3) temples (i.e., Taiwanese Folk religious, Buddhism, and Taoism temples). The inclusion of these institutional resources was based on previous studies (Chen et al., 2011; Chilenski, 2011; Leventhal & Brooks-Gunn, 2000; Moore, Diez Roux, Evenson, McGinn, & Brines, 2008). We select MRT exits rather than MRT stations because one MRT station can have several exits to the ground floor and can better reflect the concept of access to public transportation. Annual data of the number of each type of resource in 2010 were acquired from UrMap.

2.2.3. Perceived exposure to alcohol advertising

Six commercial channels of alcohol advertising were assessed at baseline, including televisions, movies, websites, billboards, magazines, and convenience stores. For each of the commercial channels, perceived exposure to alcohol advertising was assessed by a question, "During the past month, have you been exposed to alcohol advertising or alcohol promotion messages from (the commercial channel)?" Responses were coded as no (0) and yes (1). Because TV-based exposures were much more frequent than any other, we categorized these alcohol advertising channels into television and non-television channels. *Perceived exposure to alcohol advertising on other channels* at baseline was measured by summing the response from all other five commercial channels. Scores ranged from 0 to 5.

2.2.4. Individual covariates

Several individual covariates that have been previously identified as important predictors of adolescent alcohol use were assessed at baseline (Windle et al., 2009; Zucker, Donovan, Masten, Mattson, & Moss, 2008), including gender (boys/girls), monthly allowance (\geq \$NTD500/ $<$ \$NTD500) (Chen et al., 2011), living with a parent (one or none vs. both) and parental educational attainment (neither graduated college vs. either or both is a college graduate), parental approval to drink (any approval vs. none), and parental/sibling/peer drinking status (any vs. none).

2.3. Analyses

Adolescents were excluded from the analyses if they were missing data on: (1) home district or (2) lifetime drinking experience at baseline. Seven districts were excluded due to the lack of betel nut kiosk data. This resulted in a final analytic sample of 1795 participants from 22 districts. The number of students in each district ranged from 7 to 398.

Descriptive statistics were used to examine the distribution of individual and district-level characteristics. To test our hypotheses, two-level hierarchical generalized linear models (HGLMs) were used to model individuals nested in districts and to estimate bivariate and multivariable associations of perceived exposure to alcohol advertising (level 1) and district-level characteristics (level 2) to adolescent drinking behaviors for the binary outcomes of alcohol initiation and continuation in separate equations (Raudenbush & Bryk, 2002).

The analytic models were built in five stages. Stage 1: intraclass correlation coefficients (ICCs) were computed from the unconditional model (Model 0). This unconditional model describes the degree to which outcomes were clustered within districts. Stage 2: bivariate associations were evaluated. We used a sequential modeling strategy to examine the district-level effects in multivariable HGLM in Stage 3 and 4. Stage 3: The multivariable associations for perceived exposure to alcohol advertising and district-level characteristics of the intercept were estimated (Model 1), controlling for individual-level risk factors. Stage 4: cross-level

interactions between district-level characteristics (i.e., economic disadvantage and violent crime) and individual characteristics related to parenting and peer deviancy (i.e., parental drinking, peer drinking, and parental approval to drink) were included in the multivariable model (Model 2) to examine whether these individual characteristics moderated the relationships. Finally, we dropped any variables from this model that could plausibly lie in the causal pathway linking the district-level characteristics of interest to the outcome. Based on past research (Jackson et al., 2014; Mrug et al., 2010; Pickett & Pearl, 2001; Macintyre & Ellaway, 2003; Karriker-Jaffe, 2013), these individual-level variables were living with parents, parental education, monthly allowance, parental/sibling/peer drinking, and parental approval to drink. Diez-Roux cautions that multilevel studies of place characteristics and health often underestimate associations because they inadvertently include possible mediators in the models, and we wished to avoid this pitfall (Diez Roux, 2004a, 2004b). All analyses were conducted using SAS 9.4 and HLM7.0 statistical packages.

3. Results

3.1. Individual- and district-level characteristics

At the individual-level, overall 12.40% reported living with one or no parents, 53.04% had a monthly allowance more than \$NTD500 (~=\$USD16, approximately equal to 6–7 meals), and 72.13% had ever observed their parents drinking (Table 1). At the district-level, the mean violent crime rate was 22.33 (SD=8.27) incidents per 100,000 residents. On average there were 9.67 (SD=6.51) off-premises alcohol outlets and 1.17 (SD=1.53) on-premises alcohol outlets per square kilometers within districts. The number of off-premises alcohol outlets (0.45–19.18) had a higher variation than that of on-premises alcohol outlets (0.00–5.81) per square kilometers. Among 1016 alcohol-naïve adolescents at baseline, 179 (17.6%) initiated alcohol use by wave 2. Among 779 alcohol-experienced adolescents at baseline, 362 (46.5%) had used alcohol continually by wave 2.

3.2. Alcohol initiation

Table 2 shows the results of bivariate and multivariable multilevel models for alcohol use initiation. The bivariate model and models 1 and 2 suggested that adolescents were more than twice as likely to initiate alcohol use if they reported recently seeing alcohol advertising on television. After including possible individual-level risk factors in the multivariable model, model 1 suggested that adolescents in districts with a lower level of economic disadvantage (aOR=0.38; CI: 0.15, 0.98) and higher proportion of betel nut kiosks compared to off-premises alcohol outlets (aOR=1.62; CI: 1.04, 2.52) were more likely to initiate alcohol use.

The cross-level interaction model (Model 2) suggested that a higher district-level violent crime rate was positively associated with alcohol use initiation only when adolescents had observed parental drinking (aOR=1.05; CI: 1.00, 1.11). As noted, we also compared model 2 with a version of the multivariable model that excluded individual-level factors that might plausibly lie in the causal pathway (i.e., living with parents, parental education, monthly allowance, parental/sibling/peer drinking, and parental approval to drink) from model 2 (Reboussin et al., 2010; Diez Roux, 2004; Pickett & Pearl, 2001; Macintyre & Ellaway, 2003; Karriker-Jaffe, 2013). Neither the magnitudes nor the directions of the focal relationships between the district-level characteristics and the outcome differed substantially across these two models (i.e., the effect estimates did not differ more than 10% across the two models; data available upon request).

Table 1
Distribution of individual- and district-level characteristics at baseline among adolescents from the AREC II study in Taipei, Taiwan in 2010.

Variables	Total (n=1795) N (%wt) ^a	Alcohol-naïve (n=1016) N (%wt) ^a	Alcohol-experienced (n=779) N (%wt) ^a
Individual-level characteristics			
Gender (boys)	852 (47.31)	476 (46.27)	376 (48.67)
Living with parents (one or none)	222 (12.40)	98 (9.53)	124 (16.26)
Parental education (both under college)	571 (30.82)	313 (29.57)	258 (32.45)
Monthly allowance (≥500 NTD) ^b	931 (53.04)	465 (46.83)	466 (61.06)
Parental drinking (one or both)	1257 (72.13)	636 (64.48)	621 (82.10)
Elder sibling drinking (any) ^c	215 (12.55)	62 (6.31)	153 (20.54)
Peer drinking (any)	327 (18.05)	89 (8.72)	238 (30.26)
Parental drinking approval (one or both)	309 (17.62)	60 (5.97)	249 (32.85)
Exposure to alcohol advertising			
Televisions (yes)	1603 (89.39)	900 (88.62)	703 (90.38)
Other channels, Mean (SD) (range: 0–5)	2.96 (0.02)	2.80 (0.03)	3.17 (0.07)
Drinking in the past 12 months (wave II)	541 (29.69)	179 (17.30)	362 (45.83)
District-level characteristics (n=22)^d			
Social environment			
Economic disadvantage index (range: –1 to 1)	0.00 (1.00)		
Violent crime rate	22.33 (8.27)		
Alcohol access environment			
On-premises alcohol outlets density	1.17 (1.53)		
Off-premises alcohol outlets density	9.67 (6.51)		
Betel nut kiosks to off-premises alcohol outlets ratio	1.08 (1.02)		
Institutional resource environment			
MRT density	1.18 (1.60)		
Recreational resource density	1.89 (1.63)		
Temple density	0.40 (0.32)		

^a %wt: weighted percentage.

^b NTD: New Taiwan Dollar (1 USD is approximately equal to 30 NTD).

^c 856 (50.28%) participants did not have an older sibling and were regarded as not applicable.

^d Adolescents with different alcohol consumption status all lived in the same set of the 22 districts. Therefore, the district-level characteristics were not stratified by alcohol consumption status.

3.3. Alcohol continuation

Table 3 presents the results of bivariate and multivariable multilevel models for continued alcohol use. The multivariable model indicated that perceived exposure to alcohol advertising was not associated with alcohol use continuation. Model 1 indicated that adolescents living in districts with greater spatial access to off-premises alcohol outlets (aOR=1.14; CI: 1.05, 1.24) were more likely to use alcohol continually, while those living in districts with better spatial access to MRT exits (aOR=0.47; CI: 0.024, 0.92) and temples were less likely to use alcohol continually

Table 2
Hierarchical generalized linear models predicting initiation of alcohol use at wave 2 among the alcohol naïve adolescents at baseline in Taipei, Taiwan between 2010 and 2012.

Variables	Bivariate		Model 0 aOR (95% CI)	Model 1		Model 2 ^a	
	cOR (95% CI)	P-value		aOR (95% CI)	P-value	aOR (95% CI)	P-value
Fixed effects							
Level-1 (individual) variables							
Gender (boys)	0.96 (0.70, 1.33)	0.810		0.98 (0.68, 1.42)	0.928	0.98 (0.67, 1.43)	0.912
Living with parents (one or none)	1.57 (0.96, 2.57)	0.074		1.35 (0.77, 2.37)	0.295	1.44 (0.82, 2.55)	0.209
Parental education (both under college)	1.33 (0.94, 1.90)	0.107		1.32 (0.88, 1.97)	0.177	1.38 (0.91, 2.08)	0.129
Monthly allowance (\geq \$NTD 500)	1.55 (1.12, 2.15)	0.008		1.69 (1.18, 2.44)	0.004	1.74 (1.20, 2.51)	0.003
Parental drinking (one or both)	1.05 (0.75, 1.48)	0.760		0.89 (0.61, 1.32)	0.570	0.96 (0.62, 1.48)	0.840
Elder sibling drinking (any)	1.53 (0.82, 2.85)	0.180		1.49 (0.72, 3.11)	0.284	1.44 (0.67, 3.09)	0.355
Peer drinking (any)	1.62 (0.97, 2.70)	0.065		1.77 (0.99, 3.17)	0.054	1.78 (0.96, 3.30)	0.067
Parental approval to drink (one or both)	1.19 (0.62, 2.30)	0.600		1.26 (0.59, 2.66)	0.552	1.17 (0.43, 3.20)	0.752
Exposure to alcohol advertising							
Televisions (yes)	2.81 (1.41, 5.62)	0.003		2.35 (1.05, 5.25)	0.038	2.39 (1.06, 5.38)	0.036
Other channels	1.11 (1.00, 1.23)	0.060		1.08 (0.95, 1.23)	0.242	1.08 (0.95, 1.23)	0.240
Level-2 (district) variables							
Social environment							
Economic disadvantage index	0.87 (0.67, 1.14)	0.296		0.38 (0.15, 0.98)	0.046	0.37 (0.14, 0.97)	0.044
Violent crime rate	1.00 (0.98, 1.03)	0.921		1.05 (0.99, 1.11)	0.086	1.05 (0.99, 1.11)	0.095
Alcohol access environment							
On-premises alcohol outlets	1.04 (0.88, 1.22)	0.660		0.89 (0.55, 1.45)	0.626	0.88 (0.53, 1.46)	0.594
Off-premises alcohol outlets	1.01 (0.97, 1.05)	0.658		1.04 (0.95, 1.14)	0.357	1.05 (0.95, 1.15)	0.312
Betel nut kiosks	1.05 (0.82, 1.35)	0.689		1.62 (1.04, 2.52)	0.036	1.68 (1.05, 2.67)	0.033
Institutional resource environment							
MRT	1.30 (1.00, 1.70)	0.052		0.81 (0.41, 1.62)	0.526	0.78 (0.39, 1.57)	0.452
Recreational resources	1.01 (0.88, 1.16)	0.850		0.74 (0.48, 1.13)	0.151	0.75 (0.48, 1.16)	0.171
Temples	0.40 (0.17, 0.95)	0.038		0.30 (0.09, 1.02)	0.052	0.31 (0.09, 1.08)	0.063
Cross-level interactions							
Parental drinking \times economic disadvantage						0.96 (0.56, 1.63)	0.869
Parental drinking \times violent crime						1.05 (1.00, 1.11)	0.037
Peer drinking \times economic disadvantage						1.40 (0.63, 3.10)	0.410
Peer drinking \times violent crime						0.95 (0.87, 1.03)	0.185
Approval to drink \times economic disadvantage						0.79 (0.23, 2.67)	0.698
Approval to drink \times violent crime						1.02 (0.93, 1.12)	0.648
Random effects							
Intercept (u_{0j})			0.05505	0.00012		0.00011	
Deviance ($-2LL$)			2861.84	2460.02		2486.26	
Number of parameters			2	23		33	

Statistically significant effects are printed in boldface ($P < 0.05$).

^b Sample size: individual-level: 1016; district-level: 22; ^c ICC for level-2 variance component=0.02.

^a The grand-mean centering was performed for both individual-level and district-level variables to adjust for multicollinearity.

(aOR=0.26; CI: 0.24, 0.92). None of the cross-level interactions were significant (Model 2). The magnitudes and the directions of the focal relationships did not change substantially when we dropped the set of individual-level risk factors that might plausibly lie in the causal pathway from the model 2 (i.e., the effect estimates did not differ more than 10% across the two models; data available upon request).

4. Discussion

This study is one of the first multilevel studies to examine the prospective relationships linking place-based environments and media environments with adolescent drinking behaviors in an emerging alcohol market. Consistent with our hypotheses, our analyses indicate that district-level exposures and perceived exposure to alcohol advertising predicted alcohol consumption, even after controlling for individual, family, and peer attributes. Specifically, adolescents were more likely to initiate drinking if they lived in a district with less economic disadvantage and higher proportion of betel nut kiosks compared to off-premises outlets, or

if they reported seeing more alcohol advertisements on television. In addition, our data suggest that relationship between district-level violent crime and alcohol initiation was more salient among students who had observed parental drinking. As to continued alcohol use, having better spatial access to off-premises alcohol outlets or lower spatial access to temples and to MRT exits appeared to be strong predictors.

Although the association between district-level economic affluence and initiation was contrary to our hypothesis, it has prior support in the literature (Lo et al., 2006; Snedker et al., 2009). Possibly, more economically advantaged districts may create norms supporting frequent alcohol use (Karraker-Jaffe, 2011). Another interpretation of the observed relationship is that adolescents living in more affluent districts may have more access to alcohol because their parents monitor them less (Reboussin et al., 2010). Dual career upper middle-class parents often have less time to monitor children after school and may be less engaged in children's after-school activities, especially in Taiwan, where the dual career family rate is high (Lu, Kao, Chang, Wu, & Cooper, 2008; Trim & Chassin, 2008). It should be noted that we measured the economic disadvantage environment through a created composite index from several administrative data (e.g., Census). Given

Table 3

Hierarchical generalized linear models predicting continuation of alcohol use at wave 2 among the alcohol experienced adolescents at baseline in Taipei, Taiwan between 2010 and 2012.

Variables	Bivariate		Model 0 aOR (95% CI)	Model 1		Model 2 ^a	
	cOR (95% CI)	P-value		aOR (95% CI)	P-value	aOR (95% CI)	P-value
Fixed effects							
Level-1 (individual) variables							
Gender (boys)	0.71 (0.53, 0.94)	0.018		0.66 (0.47, 0.92)	0.016	0.64 (0.45, 0.90)	0.011
Living with parents (one or none)	1.05 (0.71, 1.56)	0.806		1.02 (0.63, 1.64)	0.948	0.99 (0.61, 1.60)	0.956
Parental education (both under college)	1.05 (0.76, 1.46)	0.761		1.01 (0.69, 1.47)	0.972	1.02 (0.70, 1.50)	0.906
Monthly allowance (\geq \$NTD 500)	1.41 (1.04, 1.91)	0.026		1.24 (0.88, 1.75)	0.217	1.24 (0.88, 1.76)	0.226
Parental drinking (one or both)	1.66 (1.13, 2.43)	0.009		1.30 (0.82, 2.06)	0.261	1.68 (0.96, 2.97)	0.081
Elder sibling drinking (any)	1.84 (1.21, 2.79)	0.004		1.50 (0.92, 2.45)	0.104	1.55 (0.94, 2.56)	0.083
Peer drinking (any)	1.61 (1.16, 2.24)	0.005		1.43 (0.96, 2.12)	0.079	1.30 (0.85, 2.00)	0.543
Parental approval to drink (one or both)	1.89 (1.34, 2.67)	< 0.001		1.60 (1.07, 2.40)	0.022	1.58 (1.02, 2.45)	0.486
Exposure to alcohol advertising							
Televsions (yes)	1.28 (0.79, 2.08)	0.310		1.28 (0.67, 2.44)	0.452	1.30 (0.68, 2.50)	0.432
Other channels	1.05 (0.96, 1.16)	0.307		0.99 (0.88, 1.12)	0.895	0.98 (0.87, 1.11)	0.763
Level-2 (district) variables							
Social environment							
Economic disadvantage index	0.93 (0.68, 1.28)	0.640		0.58 (0.28, 1.23)	0.141	0.57 (0.27, 1.21)	0.070
Violent crime rate	1.01 (0.98, 1.04)	0.556		1.04 (0.99, 1.09)	0.095	1.04 (0.99, 1.09)	0.124
Alcohol access environment							
On-premises alcohol outlets	1.09 (0.88, 1.35)	0.432		0.66 (0.41, 1.04)	0.070	0.63 (0.40, 1.02)	0.058
Off-premises alcohol outlets	1.04 (0.99, 1.08)	0.114		1.14 (1.05, 1.24)	0.004	1.14 (1.05, 1.24)	0.004
Betel nut kiosks	0.95 (0.70, 1.29)	0.715		1.03 (0.70, 1.52)	0.866	1.08 (0.72, 1.64)	0.683
Institutional resource environment							
MRT	1.06 (0.77, 1.47)	0.692		0.47 (0.24, 0.92)	0.030	0.48 (0.24, 0.94)	0.034
Recreational resources	1.08 (0.91, 1.29)	0.365		0.85 (0.57, 1.28)	0.410	0.87 (0.58, 1.32)	0.487
Temples	0.46 (0.17, 1.26)	0.124		0.26 (0.24, 0.92)	0.016	0.24 (0.08, 0.69)	0.012
Cross-level interactions							
Parental drinking \times economic disadvantage						2.13 (1.00, 4.55)	0.052
Parental drinking \times violent crime						0.96 (0.90, 1.02)	0.175
Peer drinking \times economic disadvantage						0.81 (0.48, 1.38)	0.411
Peer drinking \times violent crime						1.00 (0.95, 1.05)	0.848
Approval to drink \times economic disadvantage						0.77 (0.45, 1.33)	0.355
Approval to drink \times violent crime						1.04 (0.99, 1.10)	0.140
Random effects							
Intercept (u_{0j})			0.22308	0.00046		0.00036	
Deviance ($-2LL$)			2190.41	1871.33		1902.54	
Number of parameters			2	23		33	

Statistically significant effects are printed in **boldface** ($P < 0.05$).^b Sample size: individual-level: 779; district-level: 22; ^c ICC for level-2 variance component = 0.06.^a The grand-mean centering was performed for both individual-level and district-level variables to adjust for multicollinearity.

constructing an index to reflect the economic disadvantage environment is complicated and culture-dependent, future research replicating our methods to untangle the relationship between economic disadvantage and underage drinking in Taiwan is needed.

Our results demonstrate that the adverse effect of district-level violent crime on alcohol initiation is only observed among adolescents who had seen their parent drink. Areas with higher levels of violent crime tend to have lower levels of social control and higher rates of youth delinquency (Ingoldsby & Shaw, 2002; Lambert et al., 2004). For example, previous research has shown that living in a violent area is associated with subsequent alcohol initiation because of the affiliations with deviant peer groups (Lambert et al., 2004; Mrug & Windle, 2009). Also, adolescents who have observed their parent's drinking may have greater alcohol access in their home and a higher endorsement of positive alcohol expectancies, such as the expectation that alcohol enhances social behaviors (Chen et al., 2011; Zucker et al., 2009). Both of these socialization factors may encourage adolescents to mimic parental drinking to foster positive social interaction with

peers and amplify the adverse effects of violent crime on alcohol initiation. The significant moderating effect of parental drinking on district-level violent crime highlights the important interactive effect of family-level and place-based environments on adolescent alcohol initiation.

Spatial access to off-premises alcohol outlets around homes predicted continued alcohol use (Azar et al., 2016; Chen et al., 2010; Huckle et al., 2008; Livingston et al., 2008; Rowland et al., 2014; Tobler, Komro, & Maldonado-Molina, 2009; Wang et al., 2013), and higher proportion of betel nut kiosks compared to off-premises alcohol outlets was associated with alcohol initiation. Consistent with Availability Theory and prior research, our findings indicate that living in an alcogenic environment has a prospective impact on underage drinking (Rowland et al., 2016), but the impact varies by their prior drinking experience. Betel nut kiosks are an easy venue to obtain alcohol without photo identification, and spatial access to such a low-threshold venue appears to facilitate alcohol initiation. In contrast, off-premises alcohol outlets are influential for adolescents who used alcohol continually. Alcohol-experienced adolescents may also be

more skillful in successfully obtaining alcohol from these off-premises alcohol outlets (e.g., dressing older than their actual ages, shoulder tapping, or choosing cashiers with more than one person in line) (Forster, Murray, Wolfson, & Wagenaar, 1995).

Our findings are among the first to prospectively examine the benefits of place-based institutional resources on underage drinking in Asian countries. Consistent with our hypothesis, the proximity to MRT was associated with lower risks of continued alcohol use. Greater accessibility to MRT exits may make it easier for adolescents to reach local recreational facilities and public resources that are conducive to adolescent well-being; engagement with these resources in turn might prevent adolescent from continued alcohol consumption. Chen and colleagues also found that higher access to MRT in Taipei was associated with lower rates of alcohol purchasing among youth (Chen et al., 2011). Because of patterns of land use and development in Taipei, districts with higher access to MRT are usually commercial regions that have a higher level of social control. Perhaps residents and businesses in these districts have higher collective efficacy (e.g., better compliance with minimum age-of-sale enforcement) that discourages underage drinking (Maimon & Browning, 2012).

The observed protective effect of spatial access to temples on adolescent continued alcohol use could be explained by the collective process of religion. Traditional temples are usually located in historical urban areas and reflect the retention of a territorial sense of place and local identity in Taipei's ever-changing urban landscape. In these areas, social cohesion may be particularly high (Dell'Orto, 2002). Local residents may play guardianship roles in these historical areas, and this may deter adolescent alcohol use continuation.

We found that television-based alcohol advertisements were the most dominant form of alcohol advertising for all adolescents. However, as reported previously, this form of alcohol advertising only had a significant long-term influence on alcohol use initiation among alcohol naïve adolescents (Ellickson, Collins, Hambarsoomians, & McCaffrey, 2005; Stacy et al., 2004). Among adolescents who had already initiated drinking, future continued drinking was not significantly influenced by any form of alcohol advertising. These results align with a developmental model of alcohol use. Zucker et al. (2009) have found that, among alcohol-naïve adolescents, observational learning about alcohol through the media (e.g., seeing popular actors enjoy beer on television) is one of the major influences that determine their attitudes toward drinking and alcohol use initiation. However, advertising may not be influential for adolescents who initiated drinking during childhood (before age 13) because they generally model alcohol use through their parents or close family members (Zucker et al., 2009).

Our findings should be interpreted in light of several limitations. First, the AREC participants only lived in 54% of Taipei districts and the AREC participant response rate at baseline was low (55%). These limitations restrict our ability to generalize the findings to all adolescents in the Taipei metropolitan area. Furthermore, the results cannot be generalized to those school drop outs. Second, due to the lack of publicly available data on place-based alcohol advertising measures (e.g., exterior advertising) and the limited resolution of Google Street View imageries of exterior advertising, we were unable to assess the influence of alcohol advertising in districts (e.g., billboards). Future research may use global positioning system (GPS) techniques to conduct in-person neighborhood audits to measure the influence of place-based alcohol advertising. Third, since on-premises consumption outlets in Taiwan are not required to have a license, we were unable to obtain a complete inventory of on-premises consumption outlets. This may have limited our understanding of the influence of these outlets on adolescent alcohol consumption. Fourth, 12.9% of the thoroughfares in the studied districts were excluded from Google Street View audit because of the incomplete coverage. Google Street View tends to be more comprehensive in more densely

populated areas. As a result, we might have underestimated the number of betel nut kiosks in less densely populated districts and underestimate the impacts of betel nut kiosks on underage drinking. Fifth, there may be a bias for the retrospective self-reporting of alcohol advertising exposure.

5. Conclusions

This study opens the door for future place-based research on underage drinking in Asian contexts. Our findings have three important implications for future research and public health practice. First, despite the rapidly growing place-based research on underage drinking, few studies have explored whether and how youth-specific environments (e.g., institutional resources) and local alcohol access environments (e.g., betel nut kiosks) influence adolescent drinking patterns in Asia. Future research that clarifies which types of youth-specific and local alcohol access environments are meaningful to adolescents and that disentangles the possible mechanisms through which youth-specific and local alcohol access environments lead to underage drinking is warranted. Second, our findings suggest a greater need to implement a multifaceted alcohol use intervention that addresses both district-level and family-level risk factors. Third, in a context in which global alcohol marketing is expanding and alcohol advertising penetration continues, policy interventions should be considered and increased efforts to implement a more comprehensive regulations on alcohol advertising is urged, especially for televised alcohol-related marketing and promotion.

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