Special Section: *JGI* Scholar's Award, Category A

An Ecological Approach to Electronic Gambling Machines and Socioeconomic Deprivation in Germany

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Abstract

In Germany, gambling research has primarily focused on the broader population in prevalence studies, neglecting the importance and influence of the local socio-economic context in the development and maintenance of gambling disorders. To analyze the interplay between contextual and compositional factors in the market for electronic gambling machines (EGMs) in Germany, we assessed the EGM densities and socioeconomic deprivation in 244 local communities within Baden-Wuerttemberg. Our results suggest that EGM density is statistically associated with 3 socioeconomic determinants: The shares of migrants, unemployed, and high-school-educated people in the communities are statistically significant variables in our linear regression model, whereas younger age, male gender, and marital status exhibit no statistical associations with EGM density. The share of unemployed people is the only variable of statistical and practical significance. Our analysis advocates area-based policy measures to minimize gambling-related harm. By decreasing EGM densities in communities with high levels of unemployment, we expect to protect at-risk population strata that are most vulnerable to gambling exposure.

Keywords: EGM, ecological analysis, Germany, risk factors

Résumé

En Allemagne, les travaux de recherche sur la prévalence du jeu portent principalement sur la population générale, négligeant ainsi l'importance et l'influence du contexte socio-économique local dans l'apparition et la persistance des problèmes de jeu. Afin d'analyser l'interaction entre les facteurs contextuels et les facteurs intrinsèques du marché des machines de jeux électroniques (MJE) en Allemagne, nous avons évalué la densité de la répartition de ces appareils dans le Bade-Wurtemberg. Nos résultats donnent à penser que la densité de la répartition des MJE est reliée statistiquement à trois déterminants socio-économiques. Ceux-ci sont la proportion d'immigrants, la proportion de chômeurs et la proportion de

personnes fortement scolarisée dans une même communauté, qui se sont révélées être des variables statistiquement significatives dans notre modèle de régression linéaire, tandis que le jeune âge, l'appartenance au sexe masculin et l'état matrimonial n'ont donné lieu à aucun lien statistique avec la densité de la répartition des MJE. La proportion de chômeurs est la seule variable importante sur le plan statistique et pratique. Notre analyse défend la prise de mesures locales d'atténuation des effets nuisibles liés au jeu. Nous estimons qu'une diminution de la densité de la répartition des MJE dans les communautés présentant un taux élevé de chômage devrait contribuer à protéger les strates à risque de la population qui sont les plus vulnérables en cas d'exposition au jeu.

Introduction

In recent years, the German market for electronic gambling machines (EGMs) has increased by a respectable amount: From 2009 to 2013, the absolute number of EGMs increased from 233,000 to 263,000, while the total turnover of the gaming machine industry increased from 4,965 to 5,550 billion euros (Vieweg, 2013). In Germany, gambling is generally regulated at the federal state level. Authorities in the federal states govern the sectors of lotteries, sports betting, and casinos. EGM gambling in gaming halls, restaurants, and bars is subject to the federal laws of the German Industrial Code (Gewerbeordnung) and the Gambling Ordinance (Spielverordnung). In 2006, the fifth amendment of the Gambling Ordinance considerably improved the framework conditions of gaming operators and increased the incentives for individuals to gamble at EGMs. This was achieved primarily by introducing an accelerated game with higher stakes, profits, and losses. The negative effects of problematic gambling have been recognized as a public health concern by public authorities, and legislators have enacted a new regulatory framework to prevent the development of gambling disorders, the 2008 Interstate Treaty on Gambling (Glücksspielstaatsvertrag). The federal states revised the Interstate Treaty in 2012 (Glücksspieländerungsstaatsvertrag) to implement a more consistent gambling law to include legislative measures for the EGM sector.

Erbas and Buchner (2012) have shown that the quantity of inpatient and outpatient treatments for pathological gambling in Germany has increased significantly during the last decade. However, increased treatment seeking for pathological gambling may not be exclusively attributable to increased gambling availability. The rise in the number of treatment-seeking individuals can also be explained by increased awareness of the dangers associated with gambling. The public has been made aware of the dangers by mass media campaigns and by labels and warnings on gambling tickets. The Federal Centre of Health Education (BZgA) provides a nationwide telephone helpline and Internet self-help programs to counsel on

problematic gambling behavior. To advertise lotteries, providers have been legally obligated since 2008 to provide gambling addiction warnings and telephone helplines for those who want confidential advice. Furthermore, legal regulations require operators to display information leaflets on problematic gambling in gaming halls, and EGMs are required to display a telephone helpline linked to the BZgA. All of the above-mentioned measures have increased public awareness of gambling and produced a profound effect on treatment-seeking rates. In response, some federal states have started to finance specialized counseling centers for pathological gamblers (Buchner et al., 2015).

Multiple epidemiological studies in Germany have provided estimates of the proportion of pathological and problematic gamblers. Large community-based epidemiological studies that reported gambling prevalence rates for Germany were conducted by Bühringer, Kraus, Sonntag, Pfeiffer-Gerschel, and Steiner (2007) and Buth and Stöver (2008); other notable studies in this context include periodic studies from the BZgA (Haß, Orth, & Lang 2012), a study by Sassen et al. (2011), and the study of Pathological Gambling and Epidemiology (PAGE) conducted by Meyer et al. (2011).

To give an overview of the German gambling market, we will briefly discuss the BZgA studies. They were the only repeated cross-sectional analyses in Germany (BZgA, 2008, 2010, 2012, 2014). The four population-wide representative studies were conducted in the years 2007, 2009, 2011, and 2013 and assessed gambling behavior and gambling-associated attitudes and problems in the population aged 16 to 65 years. By using random digit-dial sampling, the study investigators collected data by means of computer-assisted telephone interviews. The sample size for each of the years 2007, 2009, and 2011 was 10,000, with only landline telephone numbers. The latest BZgA study in 2013 used a dual-frame approach, in which 10,001 landline telephone numbers and 1,500 mobile phone numbers were included in the analysis. To ensure comparability between the studies, we considered only the results of the sample with landline telephone numbers. Response rates for the BZgA studies were 63.3% in 2007, 61.6% in 2009, 59.9% in 2011, and 56.8% in 2013. Gambling participation rates in the 12 months preceding the BZgA surveys decreased significantly over time, from 55.0% in 2007 to 53.8% in 2009 to 50.7% in 2011 to 44.9% in 2013. The decline in participation rates could be observed for both genders and across all age groups. The 12-month prevalence of the most popular gambling activity, "lotto 6 out of 49," decreased significantly from 35.5% in 2007 to 28.7% in 2013. In contrast, the 12-month prevalence of gambling on EGMs has increased steadily from 2.2% in 2007 to 2.7% in 2009 to 2.9% in 2011 to 3.0% in 2013. The greatest increases were evident among young males. For example, the 12-month prevalence of EGM gambling increased for 18-to 20-year-old males from 5.8% in 2007 to 19.3% in 2013 and for 21-to 25-year-old males from 5.1% in 2007 to 14.4% in 2013.

For 2009, 2011, and 2013, the BZgA surveys assessed the severity of gambling problems with the South Oaks Gambling Screen (Lesieur & Blume, 1987). The 12-month prevalence of pathological gambling decreased from 0.45% in 2009 and

0.49% in 2011 to 0.38% in 2013. The 12-month prevalence of problematical gambling decreased from 0.64% in 2009 to 0.51% in 2011 to 0.45% in 2013. In describing the socioeconomic profiles of problematic and pathological gamblers, a multivariable analysis showed that male gender, immigration background, and being unemployed were significant predictor variables at the 5% significance level.

The German literature has primarily focused on prevalence studies to delineate the distribution of gambling across population segments. However, the population is not the only relevant focal point in an epidemiological study. For a complete epidemiological description of gambling, we need to include spatial or temporal dimensions in our analysis (Suzuki, 2012). Our analysis focuses on the viewpoint of place-based health research, which perceives gambling as a complex phenomenon with interconnected relationships between gambling activities and the social environment, consisting of not only the gambling venues, but also the socio-economic, cultural, and political contexts (Korn & Shaffer, 1999).

Contextual factors that characterize the social and physical environment of gamblers play an increasingly important role in the study of gambling by demonstrating how the local context of the neighborhood influences the gambling behavior of individuals (Marshall, 2009). One possible contextual effect that helps explain the development and maintenance of gambling disorders concerns the availability and accessibility of EGMs. Various authors have shown that employees of casino and gaming venues exhibit higher rates of gambling disorders than the general population does, providing evidence that increased exposure to gambling at an individual level is associated with gambling-related harm (Hing & Gainsbury, 2011; Shaffer & Hall, 2002; Shaffer, Vander Bilt, & Hall, 1999; Wu & Wong, 2008). Analyzing gambling at an area level, Marshall (2005) noted that gambling providers could induce demand for gambling by placing EGMs at favorable geographical locations. Increased gambling prevalence rates and higher gambling expenditures would then be supply-driven, or at least demand for gambling would be encouraged by the supply side. The location and number of EGMs are situational determinants of gambling and may explain why some people start gambling and why certain socioeconomic classes are particularly vulnerable to specific forms of gambling (Griffiths, 1999).

The proposition that the supply side encourages or induces gambling activity remains controversial. For example, Govoni, Frisch, Rupcich, and Getty (1998) found no difference in the prevalence rates of pathological and problem gambling or the per capita gambling expenditure after a new casino opened, whereas Ladouceur, Jacques, Ferland, and Giroux (1999) established an association between increased opportunities for gambling and the prevalence of pathological gambling. Other studies have established significant associations between gambling problems and residential proximity to casinos (Welte, Barnes, Wieczorek, Tidwell, & Hoffman, 2007; Welte, Wieczorek, Barnes, Tidwell, & Hoffman, 2004), as well as between gambling prevalence and per capita density of EGMs (Storer, Abbott, & Stubbs, 2009). Vasiliadis, Jackson, Christensen, and Francis (2013) reviewed the existing empirical literature on the interrelation between physical accessibility and gambling

involvement in Australia, Canada, New Zealand, Norway, and the United States and reiterated the substantiated evidence of a positive relationship between higher EGM density and higher gambling participation and expenditure.

In addition to the inclusion of contextual effects, gambling behavior at an area-unit level can be described by compositional factors such as socioeconomic characteristics or lifestyle-related variables of the local population (Welte, Wieczorek, Barnes, & Tidwell, 2006). For instance, various international studies have shown that EGM density is higher in socioeconomically deprived areas (Pearce, Mason, Hiscock, & Day, 2008; Wardle, Keily, Astbury, & Reith, 2014; Wheeler, Rigby, & Huriwai, 2006). Socioeconomic characteristics of the area, such as the unemployment rate, may also be considered risk factors. These variables predict or are closely associated with the development and maintenance of gambling disorders, and there are many ways to select variables in order to measure relative deprivation. For example, to assess ecological associations between small-area population characteristics and the location of gaming machines, Wheeler et al. (2006) used New Zealand's Deprivation Index, which is composed of census-based measures of income, unemployment, amenity access, and education. In addition to socioeconomic risk factors, we can also include other risk factors in our analysis, such as genetic vulnerabilities (Lobo & Kennedy, 2009), neurobiological factors (Iancu, Lowengrub, Dembinsky, Kotler, & Dannon, 2008), and personality traits and disorders (MacLaren, Fugelsang, Harrigan, & Dixon, 2011), as well as mental and substance use disorders (Dowling et al., 2015). Not all of the above-mentioned factors are available at the aggregate level. Hence, our analysis focused on socioeconomic factors, where group-level data were collected and made available by the Federal Statistics Office of Germany and the Statistical Offices of the federal states. To the best of our knowledge, no German study has examined the spatial variation of EGMs. Therefore, we set out to analyze the statistical associations between EGM densities and socioeconomic characteristics in small-area units.

Method

Regional Data for the State of Baden-Wuerttemberg

For our analysis, we focused on the state of Baden-Wuerttemberg (BW), one of 16 federal states in Germany. The state of BW lies in southwestern Germany and is bordered by the states of Rhineland-Palatine to the northwest, Hessen to the north, and Bavaria to the east; it shares borders with two countries, France to the west and Switzerland to the south (see Figure 1). BW is the third largest of the federal states, with an area of 35,751 square kilometers and a population of approximately 10.8 million people.

Because our ecological study design used aggregate-level data, as our unit of spatial analysis, we chose local communities (Gemeinden), which correspond to the lowest administrative tier in BW. In total, there are 1,101 local communities in BW, but we considered only communities with populations over 10,000, leaving us with 244 local

Figure 1. The federal state of Baden-Wuerttemberg, one of 16 federal states in Germany.

communities for our analysis. Our 244 communities comprised approximately 7.3 million inhabitants, which amounts to approximately 68% of the total population of BW.

The data originated from three sources. The first data set concerned the EGM locations in BW and was compiled by Trümper and Heimann (2012), who restricted their analysis to communities with a population of at least 10,000. For each of these 244 communities, they gathered information regarding the granted gambling concessions and the number of gambling establishments and EGMs from the respective public order offices (Ordnungsamt; effective date: January 1, 2012). A total of approximately 31,000 EGMs were included in our analysis.

The community data sets for our socioeconomic variables originated from the publicly available 2011 European Union Census and from data files for 2012 that were made available to us by the Statistical Office of BW upon our request.

Socioeconomic Risk Factors for Germany

We used the PAGE study to derive valid socioeconomic risk factors for our regression models (Meyer et al., 2011). With 15,023 participants, the PAGE study included the largest community-based sample in Germany. It used computer-assisted telephone interviews with a stratified and clustered sampling design conducted from January 2010 to March 2011, and it included individuals between 14 and 64 years of

age. Of the interviews with the 15,023 participants, 14,022 were based on landline telephone numbers and 1,001 were based on mobile phone numbers, with the aim of including disadvantaged populations that did not have landline telephones. For the landline telephone survey, the response rate was calculated at 44.5% and the cooperation rate at 54.6%. For the mobile phone survey, the response rate stood at 36.8% and the cooperation rate at 57.3%. Using the guidelines of the American Psychiatric Association, the PAGE study categorized gambling severity according to the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV*; American Psychiatric Association, 1994). The researchers categorized the severity of gambling problems into two subthreshold categories of gambling problems: one with one or two symptoms and one with three or four symptoms from the *DSM-IV*. Pathological gambling was defined by the presence of five to 10 symptoms from the *DSM-IV* criteria. In total, the 12-month prevalence rates for pathological gambling stood at 0.3% in comparison to subthreshold gambling problems with one or two criteria at 1.4% and three to four criteria at 0.3% (Meyer et al., 2011). As expected, the lifetime prevalence rates were substantially higher, standing at 1.0% for pathological gambling, 5.5% for subthreshold gambling with one to two criteria, and 1.4% for subthreshold gambling with three to four criteria. Meyer et al. (2011) used a multinomial logistic regression to quantify the relative risk for pathological gambling in relation to given sociodemographic risk factors; Table 1 summarizes their results with respect to the diagnosis of lifetime pathological gambling.

Table 1

Multinomial Logistic Regression of Lifetime Diagnosis of Pathological Gambling on Socioeconomic Risk Factors

Socioeconomic risk factor	*OR*	95% CI	*p*
Age	0.96	[0.95, 0.98]	< .001
Gender			< .001
Male	10.71	[5.42, 21.17]	
Female	Reference value		
School education			.003
<10 years education	2.43	[1.46, 4.05]	
10 years education	1.97	[1.21, 3.20]	
>10 years education	Reference value		
Marital status			.87
Married	1.06	[0.52, 2.14]	
Unmarried/divorced	Reference value		
Migration background			.002
Yes	2.32	[1.39, 3.86]	
No	Reference value		
Unemployment status			< .001
Yes	3.26	[1.74, 6.08]	
No	Reference value		

Note: The lifetime diagnosis of pathological gambling was the dependent variable in this model, with 1 = lifetime diagnosis and 0 = no lifetime diagnosis. *OR* = odds ratio; CI = confidence interval. Adapted from Meyer et al. (2011).

For the PAGE study, Table 1 shows that the odds ratios associated with younger age, male gender, less school education, migration background, and unemployment status are statistically significant at the 5% level ($p < .05$).

Consistency of the socioeconomic risk factors.   Socioeconomic risk factors may vary according to the types of gambling, implying that not all forms of gambling are homogeneous (Moragas et al., 2015). We needed to make sure that the socio-economic risk factors from the PAGE study accurately described the profile of EGM players. In the PAGE study, the participants were interviewed about different forms of gambling such as poker, lotteries, sports and horse betting, and illegal gambling. Meyer et al. (2011) used refined models and analyses to determine which gambling type was associated most significantly with gambling disorders. First, in a multivariate logistic regression for the diagnosis of lifetime pathological gambling, the participants who self-reported more than 10 days of gambling activity demonstrated that gambling on EGMs was the most significant variable associated with pathological gambling, exhibiting the highest odds ratio (odds ratio = 6.3, 95% confidence interval [CI] [4.1 , 9.8], $p < .01$), followed by poker (odds ratio = 5.0, 95% CI [2.8 , 8.9], $p < .01$). Second, pathological gamblers were asked to self-report which of the gambling forms had the strongest impact in developing their gambling problems. A total of 108 of 116 pathological gamblers offered an answer, with the majority ($n = 54$ pathological gamblers) designating EGMs as the most significant contributor in developing gambling problems, followed by poker in second place ($n = 16$ pathological gamblers).

Ecological Analysis

Selecting variables from the PAGE study and using them in an ecological analysis makes sense because a community-based analysis offers a good starting point to assess the significance of risk factors at the ecological level. In contrast, the indiscriminate choice of explanatory variables may lead to spurious correlations and unfounded statistical associations at the ecological level.

We needed to translate the variables from Table 1 into operable aggregate-level variables. For our model, we defined younger age as the share of 15- to 29-year-olds in each community population. "Male gender" referred to the share of males in each community, and the share of migrants and unemployed individuals in the communities represented the risk factors "migration background" and "unemploy-ment status" from the PAGE study. "School education" was captured by the share of high school graduates in the community, with high school graduation referring to finishing the 12 to 13 required years of secondary education in Germany (*Abitur*). At the individual level, marital status was not a predictor for a lifetime diagnosis of pathological gambling in the PAGE study ($p = .87$, cf. Table 1). Nevertheless, we used the share of married persons in our ecological study to assess whether this variable was associated with EGM density at an aggregate level. All of our socioeconomic risk factors were expressed per 1,000 individuals to remove variations

Table 2

Description of Variables for Our Ecological Analysis

Dependent variables	
EGM density	Number of EGMs per 1,000 population for each community
Independent variables	
Younger age	Number of 15- to 29-year-olds per 1,000 population for each community
Male gender	Number of males per 1,000 population for each community
High school graduation	Number of high school graduates (*Abitur*) per 1,000 population for each community
Marital status	Number of married persons per 1,000 population for each community
Migration background	Number of persons with migration background per 1,000 population for each community
Unemployment status	Number of unemployed persons per 1,000 population for each community

Note: EGM = electronic gambling machine.

arising from differences in population size across communities. Table 2 summarizes information regarding the variables that we used in our ecological analysis.

For the 244 communities in BW, Table 3 displays the mean, standard deviation, minimum, and maximum of our variables.

Statistical Methods

To analyze our data, we used the ordinary least squares method in a multiple linear regression model. Because all of our data were continuous, we assessed the statistical significance using Student's two-tailed t test, with the significance level set to .05. We did not adjust alpha levels to compensate for the familywise error rate, as this would have compromised the statistical power of our analysis. Effect sizes were quantified by the unstandardized coefficients of the regression model, as well as by the unadjusted and adjusted coefficients of determination. We confirmed the validity of the regression model, but those results are not shown here; that is, we tested for the absence of heteroscedasticity and multicollinearity, the independence and normality of the error terms, and the proper model specification. The statistical program STATA 13 was used for the analyses.

Results

A multiple regression analysis for 244 communities in BW was conducted to evaluate the relationship between EGM density and the socioeconomic risk factors of younger age, male gender, high school graduation, marital status, migration background, and unemployment status. The regression equation was found to be statistically significant, $R^2 = .29$, adjusted $R^2 = .27$, $F(6, 237) = 15.8$, $p < .001$. The results of the regression model are depicted in Table 4.

Table 3

Description of the Data Set for Our Ecological Analysis

Socioeconomic risk factor	M	SD	Minimum	Maximum
EGM density	4.0	2.6	0.2	16.0
Younger age	172.1	17.3	137.0	301.0
Male gender	490.6	7.4	463.4	510.0
High school graduation	160.9	59.0	68.1	515.0
Marital status	479.1	26.0	347.0	527.6
Migration background	98.3	33.3	31.6	209.0
Unemployment status	20.4	5.1	8.5	40.9

Note: EGM = electronic gambling machine.

Table 4

Linear Regression of EGM Density on Socioeconomic Risk Factors for 244 Communities in Baden-Wuerttemberg

Socioeconomic risk factor	b	95% CI	SE	p
Younger age	0.003	[-0.022, 0.029]	0.013	.806
Male gender	-0.027	[-0.072, 0.017]	0.023	.226
High school graduation	-0.014	[-0.021, -0.008]	0.003	< .001
Marital status	-0.013	[-0.032, 0.007]	0.010	.203
Migration background	0.020	[0.011, 0.030]	0.005	< .001
Unemployment status	0.140	[0.076, 0.205]	0.033	< .001

Note: EGM = electronic gambling machine; *b* = unstandardized regression coefficient; CI = confidence interval.

Of six socioeconomic risk factors, only three were statistically significant at the 5% level. All other things being equal, communities with larger shares of unemployed individuals or migrants were significantly associated with higher EGM densities ($p < .001$), whereas the share of high school graduates in communities was negatively associated with EGM densities ($p < .001$). The remaining three socioeconomic risk factors—i.e., the share of males, married, and younger people in the communities— failed to reach statistical significance.

As every socioeconomic risk factor was measured in the same units, we were able to compare the unstandardized regression coefficients for each factor. The variable of unemployment status, as indexed by its unstandardized coefficient of 0.140, was shown to have the strongest relationship to EGM density. This indicated that for every additional unemployed person per 1,000 individuals, there was a predicted increase in the quantity of EGMs by 0.140 per 1,000 individuals. In comparison, the unstandardized coefficients of the statistically significant variables of migration

background (b = 0.020, $p < .001$) and high school education (b = -0.014, $p < .001$) were considerably smaller.

The CIs in Table 4 provided a range of plausible values for the regression parameters. The 95% CI suggests that if we were to repeat the analysis over and over, the CI would contain the true parameter 95% of the time. The 95% CI for unemployment status was [0.076, 0.205], suggesting that the quantity of EGMs in the communities was raised by at least 0.076, and perhaps by as much as 0.205 per 1,000 individuals. For the statistically significant variables of migration background and high school education, and the nonsignificant variables of younger age, male gender, and marital status, the smallest lower limit of the CIs stood at -0.072 and the highest upper limit at 0.030. The highest upper limit of 0.030 belonged to the variable of migration background. It was considerably smaller than the upper limit of the unemployment status and hence practically nonsignificant. The smallest lower limit of -0.072 for the variable of male gender might have been of practical significance, yet the CI contained the value of 0, nullifying the statistical and practical significance of the effect size. Thus, of the socioeconomic risk factors in our analysis, only the unemployment status was both statistically and practically significant. Table 5 illustrates paradigmatically the communities with the five top and bottom numbers of EMGs per 1,000 population, alongside the share of unemployed people.

The descriptive statistics confirm the regression results. The communities with the top five EGM densities consistently had greater unemployment shares than did the communities with the bottom five EGM densities.

Table 5

Communities with Top and Bottom Five EGM Densities, Alongside Unemployment Statistics

Community	EGMs per 1,000 population	Unemployed per 1,000 population
Top Five		
Kehl	16.0	26.3
Oehringen	15.4	22.8
Riedlingen	13.7	25.0
Geislingen	11.9	27.7
Waldshut-Tiengen	10.1	23.3
Bottom Five		
Leingarten	0.4	15.6
Heddesheim	0.3	20.0
Gundelfingen	0.3	18.2
Kraichtal	0.3	15.5
Ubstadt-Weiher	0.2	13.6

Note. EGM = electronic gambling machine.

Discussion

Practical Conclusions

Starting from an evaluation of socioeconomic risk factors in the PAGE study, we used those individually based variables at the group level and assessed their usefulness in an exploratory analysis. For the first time in Germany, we used an ecological study design to investigate the associations between EGM density and socioeconomic deprivation at the community level.

Our analysis demonstrates a statistically significant association between EGM density and the three socioeconomic risk factors of unemployment status, migration background, and high school graduation. Judging from the effect size indices, only unemployment status is also of practical interest. With an average density of four EGMs per 1,000 individuals in the 244 communities of BW (cf. Table 3), the increase in the quantity of EGMs per additional unemployed individual ($b = 0.140$) is of considerable practical significance. The importance of unemployment status at the aggregate level is in line with findings from other ecological correlation studies (Pearce et al., 2008; Wardle et al., 2014; Wheeler et al., 2006). The results of our study provide preliminary indications that gambling providers place EGMs at geographical locations with relatively high unemployment rates. Further research should investigate whether this relationship also holds true for other geographical areas in Germany.

We cannot establish statistically or practically significant ecological correlations between EGM density and the share of married, male, or younger people. This is in contrast to other community-based epidemiological studies that have consistently associated gambling disorders at the individual level with younger age and male gender (e.g., Blanco, Hasin, Petry, Stinson, & Grant, 2006; Kessler et al., 2008). However, these individually based risk factors do not necessarily hold at an ecological level. The atomistic fallacy in epidemiological research describes situations in which associations between variables at the individual level may differ from associations between variables measured at the ecological level (Diez Roux, 2002). Therefore, in some cases, we may not be able to predict the behavior of groups from the behavior of individuals.

One possible solution is to reexamine statistical associations at a finer scale of ecological analysis. In future studies, we can investigate whether statistical associations exist at the city level, similar to the study of Gilliland and Ross (2005), which assessed the spatial distribution of EGMs and the socioeconomic conditions for the municipalities of Montreal and Laval. For example, Stuttgart, the state capital of BW, would provide an ideal field for carrying out an ecological gambling study. If the socioeconomic risk factors of male gender, marital status, and younger age remain nonsignificant at the city level, we can approve their nonsignificance at the ecological level with greater confidence.

Our analysis is only a starting point for investigating the complex set of interactions between socioeconomic area characteristics and EGM density. Caution is advised when moving from statistical associations at an ecological level to causal interpretations and relationships. In order to strengthen the evidence base for a relationship between socioeconomic deprivation and environmental exposure to EGMs, further longitudinal or repeated cross-sectional studies need to assess how changes in the socioeconomic environment affect the distribution of EGMs. An extension of our ecological model includes time as an important constituent of a time-geographical model. Spatial interdependencies likely vary over space and time, and it is important to identify the most crucial places and environmental contexts over different times to help estimate gambling exposure most effectively (Cummins, 2007).

Studies that examine how participation rates and gambling problems evolve over time provide another valuable research direction. International studies showed that an expansion of EGMs and increased exposure to gambling lead to rapid increases in gambling participation and problem gambling at first, followed by an adaptation period with gradual reductions in gambling participation and problem gambling rates (LaPlante & Shaffer, 2007; Shaffer, Labrie, & LaPlante, 2004; Storer et al., 2009). Factors that scholars believe influence the gradual adaptation of society to gambling include increased public awareness of problem gambling, informal social controls, expansion of treatment and self-help organizations, and regulatory and public health measures (Abbott, Stone, Billi, & Yeung, 2015). In a meta-analysis of 34 surveys in Australia and New Zealand, Storer et al. (2009) demonstrated that increased problem gambling prevalence rates are linked to higher EGM density. However, in a multivariable regression analysis, they also showed how problem gambling prevalence decreased over time at a rate of 0.09% per annum. In a meta-analysis of 202 studies from 1975 to 2012, Williams, Volberg, and Stevens (2012) affirmed the decrease in gambling participation and problem gambling rates. The downward trend began in the late 1990s in North America and in the early 2000s in Australia and Europe.

The authors of two recent studies in Sweden and Australia only partially affirmed the adaptation hypothesis. In comparing the results of the Swedish Gambling Study in 1997–1998 and the Swedish Longitudinal Gambling Study in 2008–2009, Abbott, Romild, and Volberg (2014) showed that past-year gambling participation declined from 88.0% to 71.6%, whereas past-30 days participation in EGMs increased from 3.0% to 4.0%. The authors found, contrary to the prediction of the adaptation hypothesis, a statistically significant increase in the prevalence of lifetime probable pathological gambling from 1997–1998 to 2008–2009, with no significant changes in the prevalence of lifetime problem gambling and of 12-month probable pathological or problem gambling.

For Australia, Abbott et al. (2015) compared the results of the 2003 Victorian Longitudinal Community Attitudes Survey and the 2008 Victorian Gambling Study

and found significant reductions in gambling participation rates for the previous 12 months, as well as for the monthly and weekly participation frequencies. Gambling participation on EGMs for the previous 12 months decreased from 33.4% in 2003 to 21.5% in 2008, affirming the adaptation hypothesis. Here again, in contrast to the predictions of the adaptation hypothesis, there is no evidence of prevalence rate reductions in problem and moderate-risk gambling.

For Germany, the BZgA studies offer insight into the processes of exposure and adaptation (BZgA, 2014). The repeated cross-sectional analyses allow us to monitor patterns of change over time. Gambling participation rates in the 12 months preceding the surveys decreased from 55.0% in 2007 to 44.9% in 2013, affirming the adaptation hypothesis. Contrary to the general trend of decreasing participation rates in nearly all gambling activities, the 12-month prevalence of EGM gambling steadily increased from 2.2% in 2007 to 3.0% in 2013. The increases in 12-month prevalence rates of EGM gambling were most evident in 18- to 20-year-old males and 21- to 25-year old males. In the first group, the prevalence rate quadrupled from 5.8% in 2007 to 23.5% in 2013, and in the second group, it more than doubled from 5.1% in 2007 to 12.8% in 2013. It is interesting to note that the prevalence rate for the male age group of 26- to 35-year-olds increased only slightly from 5.8% in 2007 to 7.7% in 2013. How differential exposures and vulnerabilities to EGMs lead to gender and age disparities merits a systematic analysis. Does increased EGM availability explain the rise in prevalence rates among males aged 18 to 20 and 21 to 25 years? Is the male age group of 26- to 35-year-olds not vulnerable to increased EGM exposure, or has the process of adaptation decreased prevalence rates? It is also possible that the lower prevalence rate for the 26- to 35-year-old males is biased downward because the age bracket covers a 10-year range, whereas the 18- to 20-year bracket covers only a 3-year range and the 21- to 25-year bracket covers only a 5-year range. In epidemiological terms, we need to exhibit the changes in prevalence rates over time by age-period-cohort modeling strategies. In decomposing age, period, and cohort effects, we might be able to determine why certain age groups are more susceptible to increased EGM availability and which age groups are less affected or more able to adapt to the negative effects of gambling by an accumulation of exposure experience.

As far as problematic and pathological gambling behavior is concerned, the adaptation hypothesis seems not to hold from a viewpoint of statistical significance, although a trend is observed toward lower rates. The 12-month prevalence of pathological gambling in the BZgA studies decreased from 0.45% in 2009 and 0.49% in 2011 to 0.38% in 2013. The 12-month prevalence of problematical gambling decreased from 0.64% in 2009 to 0.51% in 2011 to 0.45% in 2013. The decreases in the proportion of problem and pathological gamblers in both male and female respondents were statistically nonsignificant at the 5% level.

With the 2012 Interstate Treaty on Gambling, legislators plan to implement harm minimization policies based on geographical criteria. The minimum distance regulation in BW obliges gaming halls to keep a straight-line minimum distance of

500 m from each other, as well as from child and youth facilities. These provisions will come into effect after a transitional period that ends in July 2017, with some experts expecting a 55% reduction in the number of EGMs and a 68% reduction in the number of gaming halls (Becker & Heinze, 2015; Vieweg, 2013). Area-based policies and locally targeted interventions offer promising possibilities to combat gambling problems; on the basis of our results, public authorities should focus on decreasing EGM density in communities with relatively high unemployment rates.

To support our policy recommendation, we refer to a principle that originated from German national environmental law during the 1970s (Myers, 2002): The "principle of precaution," translated from the German word *Vorsorgeprinzip*, found its way into international law in the fields of environmental policy, natural resource management, and biodiversity conservation and more recently emerged as a principle of international law in international treaties and national policy statements (Andorno, 2004). The precautionary principle calls for preventive measures in public health affairs whenever potential harm to human health or the environment may be anticipated. This principle of practical decision making provides policymakers with the guidance to forestall potential adverse effects in the face of uncertainty of impact and causality.

We have reasonable grounds for concern that increased availability of EGMs raises the threat of gambling-related harm to human health. With the precautionary principle, we err on the side of caution, shifting the burden of proof about absence of harm from the public to the gambling industry. Policy makers should not wait until evidence of gambling-related harm from increased EGM availability is established beyond all reasonable doubt before taking preventive measures. Instead, they are permitted to act on the basis of evidence that is not conclusive.

Directions for Future Research

Future research should focus on two extensions to our model: multilevel and spatial regression models (Anselin, 1988; Diez Roux, 2002). Multilevel methods consider the concomitant inclusion and analysis of individual and ecological variables within a single model. In a multilevel analysis of gambling, the effect and influences of the neighborhood are a separate contextual level that acts on the individual gambling activity among the local population. For instance, living in a privileged socio-economic environment might offer a protective effect with regard to at-risk gambling because migrant populations are less likely to reside in these neighborhoods and therefore the local population is less likely to adopt the behaviors of these vulnerable populations. In addition to capturing the simultaneous effects of individual and group-level variables on individual-level outcomes, multilevel models can incorporate interactions across levels. For example, the interaction between EGM density and socioeconomic risk factors can be reciprocal in nature: Neighborhoods with a high density of EGMs might be unattractive to populations of higher socioeconomic status, and when those populations avoid living in those neighborhoods, rental costs and property prices can decrease, which in turn attracts individuals with low

socioeconomic status. By focusing on the nested structure of the data, multilevel analysis helps explain the ways that higher-level environments affect the decisions of individuals.

Whereas multilevel models consider only the correlation within neighborhoods, spatial regression models focus on the inter-neighborhood correlation structure. We expect an interaction between neighboring units that depends on geographical distance or shared borders. Future research should focus on the use of regression models with spatially varying parameters to capture the local variations over different geographical areas and to improve the understanding of local relationships and spatial variations in gambling behavior.

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