

observed in the present study, could also be additional factors for the higher risk of TB disease observed among males. Our study shows that smokers have a higher risk of developing TB disease than non-smokers, and is in agreement with the studies conducted in varying areas of the world.<sup>3,8</sup> The mechanisms are likely to involve both structural changes affecting lung function and altered immune response.<sup>9</sup> The present study also found that persons with a history of consuming alcohol in the preceding year had a 1.7 times higher risk of developing TB disease than those who had not consumed alcohol during the preceding year. Other researchers have also reported similar findings in different settings.<sup>8</sup> This may be explained by the significant inhibitory effect of alcohol on cell-mediated immunity.<sup>10</sup>

## Conclusion

Tobacco smoking and alcohol consumption appear to be significantly associated with the development of pulmonary TB disease in this marginalized population. There is an urgent need to develop and implement culturally appropriate targeted awareness raising activities in order to support efforts to control TB in the population.

## Limitations

While interpreting the study results, various limitations of the study need to be considered. The potential role of other risk factors were not investigated. While assessing the effects of the selected risk factors, the confounding effects of other potential risk factors could not be controlled for. This may have resulted in either an overestimation or underestimation of the true effects of those selected risk factors that were investigated.

## Acknowledgements

The authors are grateful to Dr Neeru Singh, Director, RMRCT, Jabalpur, Dr PR Narayanan, Former Director, TRC, Chennai and Dr AP Dash, Former Director, RMRCT, Jabalpur for their encouragement and support throughout the study. The contributions of the State Tuberculosis Officer, the WHO/RNTCP consultants and district health authorities of Madhya Pradesh are gratefully acknowledged. Thanks are also due to the staff involved in the study. The assistance provided by Mr Shailendra Jain and Mr Narayan Soni for the entry and verification of the data is acknowledged.

## Funding

This work was supported in part by the World Health Organization (WHO), with financial assistance provided by the United States Agency

for International Development under the Collaborative Model DOTS Project with WHO.

*Conflicts of interest:* None declared.

## Key points

- TB is a major public health problem among the Saharia, a primitive marginalized tribe of MP state in central India.
- However, there is no information on the risk factors for developing TB disease in this marginalized population.
- Significantly higher prevalence levels of TB disease were observed among those who smoked tobacco and/or consumed alcohol.
- These results provide vital information on selected risk factors associated with pulmonary TB disease in this population.
- The study findings highlight the need for the development of appropriate targeted awareness raising activities among this community to support TB control efforts.

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*European Journal of Public Health*, Vol. 22, No. 2, 273–278

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 doi:10.1093/eurpub/ckp232 Advance Access published on 27 January 2010

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# How do gamblers start gambling: identifying behavioural markers for high-risk internet gambling

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**Background:** The goal of this study is to identify betting patterns displayed during the first month of actual Internet gambling on a betting site that can serve as behavioural markers to predict the development of gambling-related problems. **Methods:** Using longitudinal data, *k*-means clustering analysis identified a small subgroup of high-risk gamblers. **Results:** Seventy-three percent of the members of this subgroup eventually closed their account due to gambling-related problems. The characteristics of this high-risk subgroup were as follows: (i) frequent and (ii) intensive betting combined with (iii) high variability across wager amount and (iv) an increasing wager size during the first month of betting. **Conclusion:** This analysis provides important information that can help to identify potentially problematic gamblers during the early stages of gambling-related problems. Public health workers can use these results to develop early interventions that target high-risk Internet gamblers for prevention efforts. However, one study limitation is that the results distinguish only a small proportion of the total sample; therefore, additional research will be necessary to identify markers that can classify larger segments of high-risk gamblers.

## Introduction

The availability of Internet gambling services raises public health and public policy concerns about their potential to influence the development of gambling-related addiction.<sup>1,2</sup> Among all people who have ever been exposed to gambling activities worldwide, ~5% experience some gambling-related problems and between ~0.2% and 2.1% become 'pathological gamblers' during their lifetime.<sup>3-10</sup> Early intervention efforts might successfully prevent, or at least diminish, the likelihood of developing gambling-related disorders.<sup>11,12</sup> Therefore, it is essential to identify gamblers at higher risk of developing gambling-related problems as early as possible.<sup>13</sup> Just as biomarkers indicate the presence of pathogenic biological processes, behavioural markers can indicate high probability of developing disordered gambling or more generally addiction.

A growing body of published articles has described the actual gambling behaviour of subscribers to the Internet gambling service, 'bwin' Interactive Entertainment, AG ('bwin').<sup>14-22</sup> However, only one article<sup>23</sup> identified specific behavioural markers to predict gambling-related problems among this group. Xuan and Shaffer compared the gambling behaviours of self-identified live-action Internet bettors during the month prior to closing their accounts because of gambling-related problems with the gambling behaviours of a matched sample of live-action gamblers who did not close their accounts. Live-action betting allows gamblers to follow a particular sporting event and to bet on an immediate proposition within the event while the event is occurring (e.g. betting on who will be the next man out during a cricket match). Xuan and Shaffer<sup>23</sup> found that those who closed their accounts due to gambling-related problems experienced increasing money loss, increasing stakes per bet, and increasingly shorter odds bets as the time of account closure approached. In this new study, instead of using the last segment of prospective betting patterns, we used the initial betting patterns from the same sample of gamblers used by Xuan and Shaffer.<sup>23</sup>

The syndrome model of addiction<sup>24</sup> suggests an aetiological approach to the emergence of addiction. From this perspective, antecedent distal (e.g. genetic, post-traumatic stress disorder, etc.) and proximal (e.g. reward value, psychiatric morbidity, socio-economic status, etc.) events can influence the likelihood of developing addiction. These aetiological antecedents include individual vulnerability factors (e.g. biological, psychological and social), object exposure and repeated object interaction. There is growing evidence that many distal (e.g. neurogenetic and cultural) and proximal (e.g. psychiatric morbidity) influences contribute to the development of addiction in general and gambling-related problems in particular.<sup>10,25-29</sup>

The purpose of this study is to examine some proximal features associated with gambling that might influence or relate to the emergence of addiction. Specifically, we investigate whether several gambling characteristics cluster in a reliable way during the first month of Internet gambling to identify live-action sports bettors who will later close their accounts due to gambling-related problems.

We considered four characteristics of first-month gambling to be important candidate variables that might distinguish between account closers and other gamblers: gambling frequency; gambling intensity; gambling trajectory; and gambling variability. Research has shown that gamblers vary in their gambling frequency (i.e. the number of betting days during the period of observation) and their betting intensity (i.e. the average number of bets per day). For example, LaBrie *et al.*<sup>30</sup> observed

high frequency and high intensity of gambling among the characteristics of a distinct group of most involved Internet casino bettors. Another potentially important characteristic that might identify high-risk gambling behaviour early in a sequence is gambling trajectory, i.e. the tendency to increase or decrease the amount of wagered money. LaPlante *et al.*<sup>17</sup> observed that most gamblers tend to decrease the amount of money they wager after the first 8-day period of gambling. However, the most involved sports bettors in this study (~1% of the sample) did not show this 'adaptation'; instead, they increased their betting activity. The American Psychiatric Association has identified a need to increase the amount of wagers to achieve the desired excitement previously experienced at lower levels of wagering (e.g. tolerance) or to try to make back previous losses as a criterion associated with pathological gambling.<sup>31</sup> Finally, the variability of betting might distinguish prospectively high-risk gamblers from their lower risk counterparts. Previous studies showed that a uniform, stable and consistent gambling pattern characterizes the majority of Internet gamblers.<sup>15,22,30</sup> Deviation from this prototypical behaviour pattern could be a marker that distinguishes high-risk gamblers from recreational gamblers.

Consequently, we hypothesize that gambling frequency, intensity, variability and the tendency to increase or decrease wagers (trajectory) during the first month of Internet live-action gambling, will identify reliable and meaningfully different subgroups of gamblers. In addition, we examine whether members of any of the identified subgroups are more likely to develop gambling-related problems than others.

## Method

### Participants

We selected the analytic sample from the full research cohort that included 48 114 people who opened an account with the Internet betting service provider 'bwin' during February 2005. For a complete description of this sample, interested readers should see LaBrie *et al.*<sup>15</sup> About half of the full sample (21 996 participants) engaged in live-action gambling more than three times during the 2-year observation period. Of those, 1758 formally closed an account after 1 month and before the end of a 2-year period, and 599 reported the reason for closing by selecting one of three available choices: (i) having no further interest in gambling; (ii) being unsatisfied with the service; or (iii) due to gambling-related problems. This last choice did not specify a particular range or intensity of problems. Finally, we excluded 69 participants who had less than two active gambling days during the first month. We excluded these participants because it was impossible to calculate some variables (e.g. standard deviation and trajectory) for less than two data points. Nineteen of those 69 participants reported closing their account because of gambling-related problems. The final analytic cohort consisted of 530 participants; 176 (33%) of those reported closing their account for gambling-related problems, 98 (19%) were unsatisfied with the service provided and 256 (48%) reported having no interest in gambling.

### Measures

Our gambling behaviour measures represented daily aggregates of betting activity records during the first 30 days, starting with the first live-action betting day. The daily aggregates included number of bets, amount of money wagered and winnings credited to the bettors' account for live-action betting on that day. From this available information, we calculated

four variables that describe a pattern of gambling activity: (i) frequency—total number of active days (i.e. days on which a participant placed at least one live-action bet) during the first 30 days, starting from the first day of live-action gambling; (ii) intensity—total number of live-action bets divided by frequency; (iii) variability—standard deviation of wagers; and (iv) trajectory—the trajectory of first month wagers. To calculate trajectory, we coded the active betting days sequentially (i.e. the first betting day was coded 1; the next betting day was coded 2, and so on). We then computed a linear regression model with wager as a dependent variable and a sequence number as a predictor. We used the slope coefficient of the regression model to describe the trajectory of wager. A positive slope value indicated increasing wager size; a negative slope value reflected a decreasing pattern of wager size.

In addition to these early predictors, we calculated the following variables that summarize betting behaviour for the entire period of gambling (i.e. from first live-action betting day to account closing): total wagers—sum of total stakes wagered; total number of bets—sum of bets for the whole period; average bet size—total number of bets divided by the total wagers; period of gambling—number of days from first to last betting days; and total losses—total wagers minus total winnings.

### Statistical analysis

We used a *k*-means cluster analysis to identify subgroups (clusters) of users with similar first-month gambling behaviours. We created the *k*-means clusters by associating every observation with the nearest mean. The final partition method minimizes the distances between observed scores and the cluster centres.<sup>32,33</sup> Before clustering the Internet gamblers, to assure comparability, we standardized all variables using *z* transformations. After identifying clusters, we conducted a chi-square test to identify meaningful associations between cluster membership and reason for closing an account (i.e. gambling-related problems versus other reasons)

We used the *k*-means cluster analysis to partition observations into *k* relatively homogeneous subgroups or clusters. All cases that belong to a single cluster demonstrate similar patterns of behaviours, as defined by the variables included in the cluster analysis. A major drawback of *k*-means cluster analysis is its potential instability. Consequently, to ensure the reliability of the results, we split the sample randomly into two halves and repeated the same clustering procedure for each subgroup independently. We also calculated a Kappa degree of concordance in cluster membership by comparing memberships of both subsamples separately with the memberships of the total sample. Following this procedure for 3–10 clusters, we identified a four-cluster solution as stable and reliable. The subgroup total membership concordance for subgroup one was good ( $k=0.658$ ,  $P<0.001$ ) and for subgroup two it was perfect ( $k=0.925$ ,  $P<0.001$ ).

## Results

### Demographics

The total analytic sample consisted of 44 (8%) women and 486 (92%) men. The mean age at the time of registration was 28.4 (SD=8.8), ranging from 17 to 62. The users reported that they were residents of 21 countries; the most frequent residency was Germany (53%), followed by Turkey (11%), Poland (6%) and Spain (5%). Men in the sample were younger than women [mean=28 versus 32 years old,  $t(528)=3.16$ ,  $P<0.05$ ] and placed more bets per day during the first month [6.8 versus 5.3,  $t(528)=1.98$ ,  $P<0.05$ ] [We conducted a logarithmic transformation (natural logarithm) of all variables prior to conducting a *t*-test to ensure normality of the distribution]. There were no other gender differences.

### Intercorrelations

Spearman's correlations between frequency, intensity, variability and trajectory were low to moderate (all  $r$ 's  $<0.60$ ). We found the highest correlation ( $r=0.571$ ) between variability and frequency.

**Table 1** Standardized scores of cluster centres on gambling behaviour characteristics

	Cluster 1 High activity, high variability ( <i>n</i> = 15)	Cluster 2 Low first- month activity ( <i>n</i> = 22)	Cluster 3 High activity, low variability ( <i>n</i> = 115)	Cluster 4 Moderate betting ( <i>n</i> = 378)
Frequency (days)	2.63489	-0.54361	2.39258	0.27904
Intensity (bets)	1.78653	0.03928	1.89973	0.00430
Variability (Euro)	4.40874	0.15649	0.26157	-0.04460
Slope	0.26706	-2.48611	0.14316	0.22323

### Description of clusters

As table 1 shows, the *k*-means cluster analysis identified four clusters of Internet gamblers distinguished by high versus low *z*-scores for each variable. Cluster 1 (high intensity, high variability,  $n=15$ ) contained gamblers who played frequently (mean=20 days during the first month) and intensively (mean=13.5 bets/day), with high variability of the wager sizes (mean of SD is 722 Euro) and positive trajectory (mean=0.19). Cluster 2 (low first month activity,  $n=22$ ) contained gamblers who played very rarely (mean=2.2 days). Cluster 3 (high intensity, low variability,  $n=115$ ) consisted of gamblers who played as frequently as the members of Cluster 1 (mean=19 days) and intensively (mean=14 bets/day), but bet about the same amount of money each day that they gambled [i.e. relatively low SD of wagers (mean=82 Euro) with almost no increase in the wagering size (mean=0.03)]. Finally, Cluster 4 (moderate betting,  $n=378$ ) included the majority of gamblers: those who played rarely (mean=7 days), not intensively (mean=4 bets/day), with low variability in their wager size [ $M(SD)=34$  Euro] and the trajectory close to zero (mean=0.09).

We conducted a series of *post hoc* one-way analysis of variance (ANOVAs) tests to examine the differences between the four clusters. All differences for the four primary measures were significant with *F*'s (3526) ranging from 61.6 (variability) to 149.8 (frequency) ( $P<0.001$  for all comparisons).

### Cluster groups' characteristics and association with gambling-related problems

A chi-square analysis revealed a significant relationship between cluster membership and reason for closing an account ( $\chi^2=13.58$ ,  $P<0.01$ ). We contrasted the group that closed their account for gambling-related problems with the other two account closing groups (i.e. those who reported being unsatisfied with the service and those with no interest in gambling). The vast majority (73%;  $N=11$ ) of members of the high activity, high variability cluster reported closing their accounts for gambling-related problems. This compared to only 45% ( $N=10$ , low first-month activity), 29% ( $N=33$ , high activity, low variability) and 32% ( $N=122$ , moderate betting), of members from the other three clusters. The other three clusters did not differ significantly from each other.

*Post hoc* one-way ANOVAs [All the variables except trajectory were not normally distributed. Consequently, we performed a logarithmic transformation (natural logarithm) on these variables to ensure normality.] revealed statistically significant differences between the members of each of the four clusters for the following variables that describe the entire period of gambling: total wagers [ $F(3526)=59.45$ ,  $P<0.001$ ], total bets [ $F(3526)=91.53$ ,  $P<0.001$ ], average bet per day [ $F(3526)=75.91$ ,  $P<0.001$ ] and total losses [ $F(3526)=5.05$ ,  $P<0.001$ ]. Table 2 presents the mean values of these variables for each subgroup. There was no significant difference for the period of gambling. These analyses further revealed that the members of the high-intensity, high-variability gambler subgroup wagered significantly more money than did members of other clusters ( $P<0.01$ ). Also, the member of both high intensity subgroups made more bets and placed them more frequently than the members of low first-month activity and moderate betting

**Table 2** Mean values of variables that describe gambling behaviours of different clusters for the entire period of gambling

	Cluster 1 High intensity, high variability	Cluster 2 Low first-month activity	Cluster 3 High intensity, low variability	Cluster 4 Moderate betting
Period of gambling (days)	447.33	337.86	425.78	360.33
Total wagers (Euro)	74 085.80	6317.81	23 660.03	5444.43
Total bets (N)	1165.66	165.91	1995.76	317.58
Bets per day (N)	10.65	5.42	12.64	4.92
Total losses (Euro)	4308.62	809.87	1705.85	408.42

clusters ( $P < 0.01$ ). Finally, members of the High Intensity, High Variability cluster lost more money than did members of the other clusters,  $P < 0.05$ ).

To determine whether demographic characteristics were associated with subgroup membership, we conducted a series of chi-square analyses for categorical variables and ANOVA for the continuous age variable. These analyses revealed no significant gender, nationality or primary language differences among members of the four clusters ( $P > 0.4$  for all variables). However, ANOVA demonstrated that the members of both high intensity clusters were slightly older (mean age = 30) than members of low first-month activity (mean age = 27) and moderate betting clusters (mean age = 28) ( $P < 0.02$ ).

Finally, a series of *t*-tests revealed that no single variable (frequency, intensity, variability or trajectory) was associated with closing an account due to gambling-related problems [ $t(528)$  ranged from 0.60 to 1.15, with  $P > 0.25$  in all instances].

## Discussion

The *k*-means cluster analysis identified four meaningful subgroups of Internet live-action gamblers based on their actual first 30 days of live-action betting. Gamblers characterized by high-intensity and frequency of gambling and by high variability of wager sizes were at higher risk than other gamblers to report gambling-related problems upon closing their accounts.

To our knowledge, this study is the first to use cluster analysis to identify a group of gamblers at higher risk for reporting gambling-related problems. This also is the first study to examine the first segment of a prospective period of actual betting behaviours. These results complement the findings of Xuan and Shaffer,<sup>23</sup> who investigated the last segment of a prospective period of gambling before gamblers closed their account because of gambling-related problems. Analysing the first segment of a longitudinal sequence is more critical than a later segment if the purpose of the research is to identify gamblers who might develop problems in the future, thereby providing public health workers with the opportunity to intervene at an earlier time.

Only about half of a percent of all gamblers who registered at the 'bwin' site during the 2-year period ever closed their account for gambling-related problems. The challenge, therefore, is to use these few cases to correctly identify others who might have similar problems or might develop such difficulties in the future. The high-risk subgroup that we identified in this study included only ~3% of all those gamblers who closed their accounts because of gambling-related problems. Nevertheless, identifying even a small portion of the total gamblers at-risk for developing gambling-related problems is an important step towards understanding these risks and towards identifying the larger subgroup at risk. For example, during early studies of seizure disorders, neurologists could classify the aetiology of very few accurately and most seizures remained of unknown origin. Aided by growing clinical and empirical evidence, the majority of seizures now can be classified accurately. As the evidence grows for gambling-associated risks, we expect to observe a similar phenomenon. More research will provide

scientists with the opportunity to better identify the risks of developing gambling-related problems. Perhaps even more important is that although only a minority of those who self-reported gambling-related problems demonstrated the pattern of high-intensity and high-variability gambling, those who did evidence this pattern are at very high risk to close their account for gambling-related problems later. More than 70% of the members of the distinguished cluster reported closing their account due to gambling-related problems. Being a member of this high-risk subgroup also predicted losing more money during the entire period of gambling. These findings seem to clearly identify one group of high-risk gamblers.

Although the results of this study do not reveal why high wager intensity and variability predict gambling-related problems, we can speculate that external factors (e.g. social relationships, availability of time, or monetary resources) influence gamblers with problems more than 'social gamblers'. Variability of wager sizes might reflect gamblers' desire to stop or limit their gambling or to control their impulses. Frequent gamblers who keep their daily betting sums constant presumably have more control over their gambling behaviour than do those players who dramatically change the sums they bet. This explanation is consistent with the clinical definition of excessive gambling as an impulse control disorder<sup>31</sup> and the results of several studies that demonstrated problematic gamblers often evidence periods of intensive gambling interrupted by the periods of remission.<sup>16,34</sup> However, we will need more research to clarify these issues.

An examination of the distribution of cluster centres raises the question of whether high variability might be a single variable capable of predicting account closing because of gambling-related problems. However, the results demonstrate that neither variability nor other variables taken separately are sufficient to predict gambling-related problems.

The syndrome model of addiction<sup>24</sup> suggests an aetiological approach to addiction where there are distal and proximal antecedent commonalities (e.g. neurogenetics and psychopathology), across different expressions of addiction (e.g. gambling, substance misuse and excessive eating). Therefore, the same behavioural markers that are antecedent to Internet gambling-related problems might be relevant to predict other expressions of addiction. Further studies should test this assumption by examining the early behavioural patterns of alcohol drinkers, smokers or individuals with other addiction problems.

## Limitations

This study has some limitations. We analysed only the behaviours of those who closed their accounts during the 2-year period, a very small proportion of the total sample. Although we employed account closers' self-reported gambling-related problems as an indication of actual gambling-related problems, we did not have clinical or collateral evidence about the participants' mental status (e.g. pathological gambling). Participants' self-report of having experienced gambling-related problems does not permit us to distinguish between levels 2 (e.g. subclinical) and 3 (e.g. pathological) gamblers within the public health nosology. Consequently, we conservatively suggest that the participants in this study represent level 2 gamblers; that is, these are people who report some gambling-related adverse symptoms, but an insufficient cluster of symptoms to warrant a clinical diagnosis.<sup>35</sup> Furthermore, gamblers who report symptoms insufficient to call for a clinical diagnosis are likely more diverse than those whose symptom patterns warrant a diagnosis of pathological gambling. Consequently, more research is necessary to clarify the extent of psychopathology among customers who close their accounts and select 'gambling-related problems' as the reason for their account closing. Similarly, we require more research to better understand the initial behaviours of gamblers who do not close their account but still report either gambling-related problems or demonstrate particularly dangerous gambling behaviours.

In our analysis, we used four characteristics of initial betting behaviour. However, other factors might also be candidates for identifying at-risk gamblers. These other variables might include total amount of wagers, number of winning or losing days, number of deposits made during the first month, etc. Future studies can use the predictors found by the

present analysis and other variables to build other models that can predict high-risk gambling.

Our analysis identified only a small portion of individuals with gambling-related problems. The population of problematic and pathological gamblers is likely more heterogeneous.<sup>36</sup> Levels 2 (e.g. problem) and 3 (e.g. pathological) gamblers vary in their socio-demographic characteristics, motivation, personality types as well as their patterns of betting behaviour.<sup>12</sup> Therefore, it is likely that we can generalize our results to only a small subgroup of gamblers. It is important to conduct further studies that will identify risk factors or subgroups for the non-identified 97% of gamblers with gambling-related problems.

This study used Internet gamblers from only one gambling service and these results might not generalize to other populations. Moreover, we only considered live-action bettors in our analysis. We found that there were a substantial number of users who reported closing their account for gambling-related problems who demonstrated little live-action betting activity during their first month or during the whole 2-year period of gambling. It is likely that these gamblers participated in other games (e.g. fixed odds betting) and this other betting activity was contributing to account closing.

In sum, this study advances the field of gambling research by providing a logical continuation of a series of investigations of actual betting behaviours. Our previous publications on this topic provided reports about overall gambling patterns<sup>14,15</sup> and, in particular, about the last segment of betting activities before closing an account.<sup>23</sup> In this study, we identified a subgroup of Internet gamblers at high risk for reporting gambling-related problems by using *k*-means cluster analysis. This method could be used in the future to investigate other high-risk groups using different variables that describe gambling behaviours. Further studies could confirm the findings for other types of gambling (e.g. poker and casino).

## Acknowledgements

The authors are thankful to Sarah Nelson, Debi LaPlante, Richard LaBrie, Heather Gray and John Kleschinsky for their support and thoughtful comments on previous drafts of the article. None of the supporters or any of the authors has personal interests in bwin.com and its associated companies that would suggest a conflict of interest.

## Funding

Bwin.com, Interactive Entertainment, AG provided primary support for this study. The Division on Addictions also receives support from the National Center for Responsible Gambling, National Institute on Alcohol and Alcohol Abuse, National Institute of Mental Health, Venetian Casino Resort, LLC., The Massachusetts Council on Compulsive Gambling, St. Francis House, and the University of Nevada.

*Conflicts of interest:* None declared.

## Key points

- This is the first study to use actual gambling behaviour to identify specific behavioural markers to predict gambling-related problems.
- This study used cluster analysis to identify a group of gamblers at higher risk for reporting gambling-related problems based on the characteristics of their initial stage of gambling.
- The study revealed that gamblers characterized by high intensity and frequency of gambling and by high variability of wager sizes during their first month of gambling were at higher risk than other gamblers to report gambling-related problems upon closing their accounts.

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*European Journal of Public Health*, Vol. 22, No. 2, 278–280

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 doi:10.1093/eurpub/ckq193 Advance Access published on 23 December 2010  
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## Prevalence and regional differences of gestational diabetes mellitus and oral glucose tolerance tests in Finland

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**Background:** The prevalence of gestational diabetes (GDM) is constantly increasing all around the world. Aim of this study is to report prevalence and regional differences of GDM, oral glucose tolerance tests (OGTT) and register-based GDM risk factors [age and body mass index (BMI)] among Finnish women. **Methods:** Data from the Finnish Medical Birth Register including all deliveries in Finland during 2004–06 ( $N=174\,634$ ) were used. The criteria for GDM were abnormal results in OGTT, GDM diagnosis based on ICD-10 classification or use of insulin treatment during pregnancy. Pregnant women with type I diabetes were excluded, but women with pregestational diabetes (type II) were included since they also can receive GDM diagnosis. **Results:** The prevalence of GDM was 10–11% and OGTTs 22–28% between the period 2004 until 2006. Regional differences were 2-fold both in prevalence of GDM (8–15%) and OGTTs (19–34%). Proportions of obese women varied between 28% and 35% and women aged >40 years between 3% and 4%. The regional differences in GDM prevalence were not attenuated when risk factors were taken into account. Overweight and age  $\geq$  years explained only a fourth of the variation in GDM prevalence. **Conclusion:** Proportion of women undergoing OGTT increased but the prevalence of GDM did not during the study period. Two-fold regional differences in OGTT prevalence explained higher proportion of variation in prevalence of GDM than risk factors available from birth registry, age and BMI.

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### Introduction

During past two decades, the prevalence of gestational diabetes mellitus (GDM), defined as a type of diabetes diagnosed for the first time during pregnancy, has increased from 2–5% to 3–7%.<sup>1–6</sup> In Finland, prevalence of GDM was 0.5% in 1987 and 2.2% in 1988.<sup>7</sup> According to a Finnish population-based study, the proportion of pregnant women with increased blood glucose levels was 15%.<sup>8</sup>

Decreased insulin sensitivity towards the end of pregnancy increases the risk of GDM.<sup>9</sup> The other known risk factors are maternal overweight and high age, history of earlier GDM, macrosomic child or first degree relative with a history of type II diabetes.<sup>10–12</sup> Women with GDM have an increased risk of developing type II diabetes in their later life.<sup>13,14</sup> Recent studies on GDM prevalence have reported regional variations<sup>11</sup> and associations with socio-economic characteristics of the women.<sup>15</sup>

The purpose of this study was to report the prevalence and regional differences of GDM, OGGTs and register-based GDM risk factors [age and body mass index (BMI)] among pregnant women in Finland.

### Methods

Data for the study were based on the Finnish Medical Birth Register (MBR), which has recorded all births taking place in Finland since

1987. The register includes all live births and stillbirths of >22 weeks of gestation or weighing <500 g. The coverage of the register is complete: during the study period only 0.1% of all births were not reported to the MBR, but the MBR is routinely linked to the Central Population Register (data on live births) and to the Cause-of-Death Register (data on stillbirths and early neonatal deaths), after which it is considered to be complete. Data are checked in the MBR and seemingly incorrect information is sent back to the hospitals for correction. For most variables, the data correspond well or satisfactory to information found in hospital records. Since 2004, the register has included information on whether the oral glucose tolerance tests (OGTT) were performed, as well as maternal weight and height before pregnancy.

For this study, we utilized information on diagnostic criteria of GDM, results of OGTT and possible insulin treatment during pregnancy. These criteria are overlapping, not mutually exclusive. The diagnosis was based on the international ICD-10 classification. The data on numerical results of OGTT were unavailable from the medical birth register, only information on abnormal OGTT result during pregnancy was available. Total GDM prevalence was based on the information from different fulfilled criterions of GDM. Prevalence calculations do not include women with type I diabetes. Women with pregestational diabetes (type II) were not excluded, because they also could develop GDM. Differences in GDM prevalence between the geographical areas (Southern,