SSM -Population Health 2 (2016) 217–225

Contents lists available at ScienceDirect

SSM -Population Health

journal homepage: www.elsevier.com/locate/ssmph

Article

Intraclass correlation values for adolescent health outcomes in secondary schools in 21 European countries

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ARTICLE INFO

Article history:
Received 18 November 2015
Received in revised form
9 March 2016
Accepted 10 March 2016

Keywords:
Intra-class correlation
Schools
Adolescents
Substance use
Mental health

ABSTRACT

Background: Cluster randomised controlled trials (CRCTs) are increasingly used to evaluate the effectiveness of interventions for improving health. A key feature of CRCTs is that individuals in clusters are often more alike than individuals in different clusters, irrespective of treatment. This similarity within clusters needs to be taken into account when planning CRCTs to obtain adequate sample sizes, and when analysing clustered data to obtain correct estimates.

Methods: Nationally representative data from 15 to 16 year olds were analysed, from 21 of the 35 countries that participated in the 2007 European School Survey Project on Alcohol and Other Drugs. Within country school level intra-class correlation coefficients (ICCs) were calculated for substance use (self-reported alcohol use, regular alcohol use, binge drinking, any smoking, regular smoking, and illicit drug use) and psychosocial health (depressive mood and self-esteem). Unadjusted and adjusted ICCs are presented. ICCs are adjusted for student sex and socioeconomic status.

Results: ICCs ranged from 0.01 to 0.21, with the highest (0.21) reported for regular smoking. Within country school level ICCs varied substantially across health outcomes, and among countries for the same health outcomes. Estimated ICCs were consistently higher for substance use (range 0.01–0.21), than for psychosocial health (range 0.01–0.07). Within country ICCs for health outcomes varied by changes in the measurement of particular health outcomes, for example the ICCs for regular smoking (range 0.06–0.21) were higher than those for having smoked at all in the last month (range 0.03–0.17).

Conclusions: For school level ICCs to be effectively utilised in informing sample size requirements for CRCTs and adjusting estimates from meta-analyses, the school level ICCs need to be both country and outcome specific.

1. Background

Cluster randomised controlled trials (CRCTs) are increasingly used to evaluate the effectiveness of interventions for improving health (Bland, 2004; Klar & Donner, 2001). CRCTs involve the random assignment of whole clusters, such as schools, hospitals, clinics or communities, rather than individuals (Raudenbush, 1997). CRCTs are particularly useful where researchers are specifically interested in the cluster, as it may not be feasible to randomly assign individuals to clusters such as schools or hospitals, or where they are interested in the cluster-level effects of an intervention. The advantages and disadvantages of using CRCTs have been discussed in detail in a series of publications by Donner and Klar (2001/2002/2004) (Donner & Klar, 2002; Donner & Klar, 2004; Klar & Donner, 2001). A key feature of CRCTs is that individuals in clusters are often more alike than individuals in different clusters, irrespective of treatment. This similarity within clusters needs to be taken into account when planning CRCTs to obtain adequate sample sizes, and when analysing clustered data to obtain correct estimates. The focus of this paper is on presenting estimates of the similarity of health outcomes of students within schools across a large number of European countries.

Students in the same school are more similar, on average, than students selected from different schools. This is true for a range of educational and health outcomes (McKenzie, Ryan, & Di Tanna, 2014). This dependence of individuals within clusters leads to two potential problems. First, CRCTs require more subjects than RCTs to obtain adequate statistical power because observations are not independent. Secondly, the clustering of the data needs to be addressed through the use of appropriate analysis techniques (such as multilevel models), otherwise standard error estimates

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http://dx.doi.org/10.1016/j.ssmph.2016.03.005

will be deflated resulting in an increased risk of Type I errors (false positives) (Klar & Donner, 2001; McKenzie et al., 2014).

The intra-class correlation coefficient (ICC) measures the degree of within cluster dependence for a variable, and can therefore be used in power calculations to compute the necessary sample sizes for specific outcomes for CRCTs. If all observations are independent of one another, the ICC will be 0. If all the responses from observations in all clusters are exactly the same, the ICC will be 1. For trials, the greater the value of the ICC, the greater the sample size required (Klar & Donner, 2001; McKenzie et al., 2014; Raudenbush, 1997). To achieve the equivalent power of an individual level randomised un-clustered sample, the sample size has to be inflated by the design effect:

Design Effect $= 1+(m-1)^{*}$ICC, where m represents the average cluster size.

The ICC can also be used to correct the estimates of analyses that have not taken the clustered nature of the data into account, by either retrospectively inflating the standard errors to account for the dependence, or reducing the sample size (Hedges, 2007; Hedges & Hedberg, 2007). This is potentially very important for research that compares or combines the results of analyses, such as meta-analyses. Hence it is useful to know ICCs in advance of designing CRCTs, to ensure adequate sample size for power, and for adjusting the analysis of clustered data in meta-analysis, where clustering has not been taken into account. Knowledge of ICC's is important for a further reason that is often overlooked. When interpreting the impact of school level variables in multilevel models, the lower the value of the ICC, that is the lower the proportion of the variance that is at the school level and therefore the less relevant the school context is, the more likely you are to obtain a significant association between a school-level variable and the outcome (Lagerlund et al., 2015; Merlo, Wagner, Ghith, & Leckie, 2015). Researchers need knowledge of ICC's to accurately interpret school level variables in multilevel models.

The importance of the ICC has been widely acknowledged for educational outcomes. ICCs are deemed important because they highlight the differential performance of schools (variation between schools) in terms of student achievement, conditional upon prior student achievement (Goldstein, Huiqi, Rath, & Hill., 2000). Estimates of ICCs for educational achievement in the UK range between 0.10 and 0.25, which suggests that between 10% and 25% of the total variance is at the school level (Hedges & Hedberg, 2007; Hale et al., 2014). Where researchers have reported estimates of the ICCs for health related outcomes, the estimated ICCs are significant but smaller in magnitude than for educational outcomes (Bonell et al., 2013a; Hale et al., 2014; Sellström and Bremberg, 2006). Hale et al. (2014) reported the ICCs for a range of health outcomes from three large English datasets, with the majority of the ICCs for health outcomes being lower than 0.10, compared to the ICCs for academic achievement which were between 0.19 and 0.25 in the same samples (Hale et al., 2014). Bonell et al. (2013a) performed a systematic review of multilevel school studies from the USA, Canada, the UK, Australia, Thailand, Israel and several European countries. They reported ICCs between 0.02 and 0.14 for smoking and alcohol use, and ICC's less than 0.06 for students' problem behaviour and well-being (Bonell et al., 2013a).

The similarity of students within schools may be due to selection, whereby individuals affiliate with others who have similar attributes to themselves (Simons-Morton & Farhat, 2010). Schools likely attract students with similar characteristics, hence selection into schools results in students having more similar characteristics or behavioural patterns than one would expect if selection into schools was random (Simons-Morton & Farhat, 2010). Alternatively, it may be due to socialisation processes whereby adolescent's behavioural patterns become more similar in response to interactions with other students in the same school, and the formation of perceived or actual social norms about behaviours (Simons-Morton and Farhat, 2010).

The terms "compositional effects" and "contextual effects" have also been used to explain the influence of places on individuals' outcomes (Macintyre, Ellaway, & Cummins, 2002). Compositional effects refer to the influence of the collective properties of the student body on individual student's behaviour. For example, some schools will have a predominance of students from socio-economically advantaged families, who are highly motivated and have high levels of prior achievement. This compositional aspect of the school can have a positive influence on achievement for all students in the school (Lauder, Kounali, Robinson, Goldstein, & Thrupp, 2007; van Ewijk & Sleegers, 2010). Contextual effects refers to the influence of the school itself (such as the physical environment, policies and regulations) on student's behaviour (Macintyre et al., 2002). Compositional effects link to the selection and socialisation processes outlined in the previous paragraph. Differential compositions of schools are a product of selection effects into schools (Harker & Tymms, 2004).The influence of school composition on individual student's behaviour is partially explained by socialisation processes (Harker & Tymms, 2004).

Markham and Aveyard's (2003) theory of human functioning attempts to explain the relationship between schools and student's behaviours, placing the emphasis on the contextual explanation (the effect that schools have on students). This theory is rooted in Bernstein's (1975) theory of cultural transmission. Schools impart two types of knowledge, the instructional order (acquisition of knowledge and skills), and the regulatory order (appropriate ways of behaving). Students who reject, or are unable to meet the demands of, these kinds of learning subsequently reject the values of the school and affiliate with youth subcultures that are more likely to promote substance use.

Alternatively, the notion of peer contagion effects (Cohen & Prinstein, 2006; Dishion & Tipsord, 2011) and social mimicry (Moffitt, 1993) place emphasis on the compositional elements of the school environment using socialisation processes to explain similarity in behaviours. Peer contagion effects suggests that students influence each other's behaviours and emotions, such that deviant behaviours and emotional problems are transmitted from one student to another. The transmission of behaviours is an unintended consequence of social relationships (Cohen & Prinstein, 2006; Dishion & Tipsord, 2011). A related but distinct theory is that of social mimicry, which argues that behaviours are explained through the desire for social acceptance and esteem (Moffitt, 1993).

A number of school factors have repeatedly been shown to protect against unhealthy behaviour and poor mental health, particularly school connectedness or more broadly aspects of the school 'culture' and ethos (Bonell et al., 2013a, 2013b; Viner et al., 2012). Several systematic reviews of school based interventions show the potential for schools to influence a wide range of student health and behavioural outcomes, including nutrition and activity, substance use, sexual health behaviours, and violence related outcomes (Bonell et al., 2013b; Fletcher, Bonell, & Hargreaves, 2008; Foxcroft & Tsertsvadze, 2011; Langford et al., 2014; Sellström & Bremberg, 2006). School based interventions that address the school environment are effective at changing student health behaviours (Fletcher et al., 2008; Foxcroft & Tsertsvadze, 2011; Langford et al., 2014). Higher ICCs for specific behaviours could suggest that school-level interventions are more effective in changing those behaviours, as a higher proportion of variance at the school-level suggests that the outcome is predicted by characteristics of the school as well as characteristics of the student. Although, this is only true if the ICC is not a reflection of selection effects into schools (Macintyre et al., 2002).