



Derivation of indices of socioeconomic status for health services research in Asia

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ABSTRACT

Background. Environmental contexts have been shown to predict health behaviours and outcomes either directly or via interaction with individual risk factors. In this paper, we created indexes of socioeconomic disadvantage (SEDI) and socioeconomic advantage (SAI) in Singapore to test the applicability of these concepts in an Asian context. These indices can be used for health service resource allocation, research and advocacy.

Methods. We used principal component analysis (PCA) to create SEDI and SAI using a structured and iterative process to identify and include influential variables in the final index. Data at the master plan geographical level was obtained from the most recent Singapore census 2010.

Results. The 3 areas with highest SEDI scores were Outram (120.1), followed by Rochor (111.0) and Downtown Core (110.4). The areas with highest SAI scores were Tanglin, River Valley and Newton. The SAI had 89.6% of variation explained by the final model, as compared to 67.1% for SEDI, and we recommend using both indices in any analysis.

Conclusion. These indices may prove useful for policy-makers to identify spatially varying risk factors, and in turn help identify geographically targeted intervention programs, which can be more cost effective to conduct.

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Introduction

In developed countries, various areal measures of socioeconomic status have been created, such as the Socio-Economic Indices for Australia (SEIFA) in Australia (Castles, 1994), Carstairs index in the UK (Carstairs, 1995; Morris and Carstairs, 1991), as well as indices in United States (Krieger et al., 1997) and New Zealand (Crampton et al., 1997). Such indices are useful to health practitioners and administrators for a number of reasons; mainly in the areas of resource allocation, research and advocacy. They can be used to determine funding formula for primary healthcare services, social services, relating socioeconomic status with health outcomes and risk factors/behaviours, as well as aid community-based service providers in terms of pricing and pitching the appropriate services for communities with different socioeconomic status. The use of such indices has not been studied in an Asian context where cultural norms and environmental contexts may significantly alter the usefulness of SEDI or SAI. We use Singapore as an example

for testing the conceptual applicability of these indices in a highly urban, Asian setting.

In Australia, increasing geographical socioeconomic disadvantage has been shown to be positively associated with mortality as well as hospital admissions for acute coronary syndromes, lower rates of interventions such as angiographies and interventional angiographies (Beard et al., 2008). Geographical socioeconomic disadvantage has also been shown to be related to small-for-gestational age births (Beard et al., 2009), subjects who are overweight (van Lenthe and Mackenbach, 2002), children's mental health use (van der Linden et al., 2003), incidence of coronary heart disease (Sundquist et al., 2004), maternal depressive symptoms (Mulvaney and Kendrick, 2005) as well as risk factors for adverse health outcomes such as smoking (Duncan et al., 1999). However, there have also been negative findings in studies examining the association between neighbourhood deprivation and health outcomes. An English study found that the neighbourhood context in which a mother lives has no impact on the risk of gestational diabetes (Janghorbani et al., 2006), while another study found no effect of neighbourhood deprivation and health behaviours such as exercise levels among older people (Fox et al., 2011).

Individual and areal measures may also measure different aspects of socioeconomic status that may be positively or negatively correlated with health outcomes. For instance, two birth defect studies compared

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individually measured socioeconomic status (SES) with areal measures, and concluded that the effects of individual versus areal measures were mixed. One study found a significant effect of lower individual socioeconomic status and residence in an SES-lower neighbourhood on the occurrence of neural tube defects (Wasserman et al., 1998). On the other hand, a study of neural tube and facial clefts showed an increased risk for low SES households but not at the individual level (Croen and Shaw, 1995).

The motivation for this research came from our earlier attempt to model the association between individual items of socioeconomic status from the Singapore census with Out-of-Hospital Cardiac Arrests (OHCA) from a nation-wide registry (Ong et al., 2011). We found that demographic variables, but not individual socioeconomic variables, to be associated with OHCA, which was contrary to our initial hypothesis. We suspect this was due to a large number of individual variables included in the model, and highlighted the need for an index to measure areal disadvantage. Such an index has not been developed for Asian countries, and its applicability/validity therefore remains unproven. The aim of our study was therefore to create a small area socioeconomic disadvantage index (SEDI), as well as an index of socioeconomic advantage (SAI) for Singapore, and to assess the validity of such indices in an Asian socio-cultural context.

Materials and methods

We obtained socioeconomic data from the most recent Singapore census done in 2010. The Census of Population is conducted once in 10 years by the Singapore Department of Statistics, and data is based on a person's place of usual residence. To collect additional information not available from administrative sources, some 200,000 households were selected to participate in the sample enumeration via telephone,

face-to-face interviews as well as the internet, and the census data was subjected to strict quality control checks and audits (Department of Statistics, Ministry of Trade and Industry, 2010).

For the purposes of our analysis, we used the following variables, which were indicative of socioeconomic status: housing type, highest educational level, literacy level, occupational categories, industries employed in, and personal and household income. For creating the SEDI index, we started with 23 variables, while for the SAI index, 11 variables were initially included. The SEDI has more variables mainly because there were more occupational categories for the lower socioeconomic group (Appendix 1).

The data was available at the Singapore Master Plan geographical boundary level, which is used by the Urban Redevelopment Plan (URA) authorities for town planning purposes. The URA, which is the government agency responsible for the urban planning of Singapore, released a geographical map of Singapore with demarcations of the various towns (also called master plan areas) in 2008 (Urban Redevelopment Authority, Singapore). The areal zones represented mainly residential areas (32 towns), as well as water catchment areas and smaller islands which are primarily used for commercial/army training purposes.

We used principal component analysis (PCA) to create the SEDI and SAI (Jolliffe, 1986). PCA is a data reduction technique that is used to summarise a large number of variables into a smaller group, collectively known as a principal component. A structured and iterative process was used to identify and include influential variables for inclusion in the final index as described below, mostly similar to that used in Australia (Statistics, 2006):

Step 1. Initial variable list

For each index, we created an initial variable list, which was based on information available from the census stratified by the geographical master plan regions. These were variables that were areal measures of socioeconomic disadvantage/disadvantage

Step 2. Creating variables

For each master plan, we computed variables as proportions. For instance, in Ang Mo Kio, we calculated the proportion of residents living in public housing 3 rooms or below. These proportions were then standardised to have a mean of 0 and standard deviation of 1. This was done to prevent variables with larger prevalence from having an undue influence on the overall index.

Step 3. Removing correlated variables

Next, highly correlated variables were removed to prevent instability in the variable weights. Generally, when two variables had a correlation coefficient greater than |0.9|, we removed one of them. However, in cases where we hypothesised that two different aspects of socioeconomic status were being represented, e.g. proportion cleaners and labourers (education) with proportion with household income less than S\$4000 (income), we included both variables.

Step 4. Principal component analysis (PCA)

The next step involved conducting the PCA on the set of variables identified from above, to obtain the variable loading for each variable on the first principal component. We opted not to perform component rotation, as a previous paper had found limited usefulness in creating these indices (Australian Bureau of Statistics, 2006). The variable loading is essentially the correlation coefficient between each variable and the component.

Step 5. Removing low loading variables

Starting from the variable with the lowest loading, we removed variables one at a time whenever their loading was below |0.2|. We used a threshold of 0.2 instead of 0.3 as suggested in the Australian model, in order to preserve known markers of

Table 1
Summary of socioeconomic disadvantage by planning areas.

Planning Areas	SEDI	95% CI	
Newton	79	72.8	83.9
Tanglin	79.3	75.7	82.3
River Valley	79.4	74.5	78.8
Bukit Timah	79.8	74.5	83.4
Pasir Ris	90.7	75.7	95.8
Bishan	92.8	76.8	101.3
Serangoon	94.2	75.5	105.6
Marine Parade	94.5	74.9	109.4
Novena	96.3	66.6	107.1
Choa Chu Kang	97.6	72.8	108.5
Tampines	99.8	77.7	110.9
Jurong East	99.9	73.6	109.3
Sengkang	100.2	77.8	111.8
Clementi	100.3	77.2	117.9
Bukit Batok	100.6	79.6	112.8
Sembawang	100.8	74.5	111.8
Bukit Panjang	100.9	79.4	113.8
Jurong West	101.6	78.9	112.2
Bedok	102	78.2	121.8
Woodlands	102.7	83.7	121.0
Hougang	102.8	88.7	116.4
Yishun	105.6	80.4	122.0
Changi	106.3	97.3	122.8
Queenstown	106.9	97.0	122.7
Toa Payoh	107.2	97.6	119.4
Ang Mo Kio	107.9	97.4	121.8
Geylang	109.3	103.9	123.0
Bukit Merah	110.1	107.2	122.0
Kallang	110.1	102.0	121.7
Downtown Core	110.4	103.5	121.9
Rochor	111	107.0	119.7
Outram	120.1	78.7	122.0

Note: 95% CI denotes bias-corrected confidence intervals derived from bootstrap samples. SEDI: socioeconomic disadvantage index.

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