The Swiss Neighbourhood Index of Socioeconomic Position: Update and Re-validation

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ABSTRACT

Background The widely used Swiss neighbourhood index of socioeconomic position (Swiss-SEP 1) was based on data from the 200 national census on rent, household head education and occupation, and crowding and may now be out of date.

Methods We created a new index (Swiss-SEP 2) based on the yearly micro censuses 2012-2015 that replaced the decennial house-to-house census in Switzerland since 2010. We used principal component analysis on neighbourhood-aggregated variables and standardized the index. We also created a hybrid version (Swiss-SEP 3), with updated values for neighbourhoods centred on buildings constructed after 2000 and original values for remaining neighbourhoods.

Results 1.54 million neighbourhoods were included. With all three indices, mean yearly equivalised income increased from around 52,000 to 90,000 CHF from the lowest to the highest index decile. Analyses of mortality were based on 33.6 million years of follow-up. The age- and sex-adjusted hazard ratios of all-cause mortality comparing areas in the lowest decile of Swiss-SEP with areas of the highest decile were 1.39 (95% CI 1.36-1.41), 1.31 (1.29-1.33) and 1.34 (1.32-1.37) using the old, new and hybrid indices, respectively.

Discussion The Swiss-SEP indices capture area-based SEP at a high resolution and allow the study of SEP when data on individual-level SEP are missing or area-level effects are of interest. The hybrid version (Swiss-SEP 3) maintains high spatial resolution while adding information on new neighbourhoods. The index will continue to be useful for Switzerland's epidemiological and public health research.

Keywords: Switzerland, socioeconomic position, social inequalities in health, mortality

INTRODUCTION

The association of people's socioeconomic position with their health has been recognized for a long time. The civil servant turned social reformer Edwin Chadwick reported that in 1842 Great Britain, the average age at death was 45 years in "gentlemen and persons engaged in professions, and their families", but only 16 years in "mechanics, servants and labourers, and their families" [1]. The health of populations has improved dramatically since then, but mortality and socioeconomic position continue to be associated [2]. For example, during the first decade of the 21st century, an analysis using the original Swiss neighbourhood index of socioeconomic position (Swiss-SEP 1) found substantial variation in life expectancy depending on the social standing of neighbourhoods [3,4].

The Swiss-SEP 1 index was developed using data from the 2000 census and is based on four domains that measure different aspects of the socioeconomic situation of Swiss households: Rent per square metre, education level, occupation and overcrowding [3,5]. Rent is closely related to income, which influences many exposures that affect health and health services access. Households with higher levels of education may lead healthier lifestyles. Occupation captures occupational exposures such as work stress and specific workplace exposures [6]. Crowded households tend to have fewer economic resources. There may also be direct impacts of crowding on health, such as spreading infectious diseases. Swiss-SEP 1 [3] covers 1.27 million neighbourhoods, centred on residences but with sliding boundaries that aim to capture the social and economic conditions to which individuals are exposed.

Since its publication in 2012 [3], the index has become a valuable tool in epidemiological and clinical research to examine the importance of socioeconomic position or adjust for its potential confounding effect. For example, in recent months, it has been used in studies of DNA methylation profiles associated with the vegetation (greenness) around the residential address [7], dietary patterns across Swiss language regions [8], or respiratory health in schoolchildren [9]. The continued use of an index of socioeconomic position based on data from 2000 raises the question of whether the tool is still fit for purpose. Over the past two decades, Switzerland's population grew from 7.20 million to 8.67 million [10]. Some areas might have changed their status, for example, due to the construction of new residential areas, the "gentrification" of existing neighbourhoods, or new roads or public transportation links.

In 2010, Switzerland moved from decennial censuses to a system of yearly surveys (micro censuses) [3]. Therefore, the individual and household-level information used to construct the Swiss-SEP is no longer collected for the entire population but only for a random sample of about 200,000 residents per year. This situation prevents an automatic update of the index. Here we describe the changing data ecosystem, construct new versions of the Swiss-SEP index and validate the old and new versions against independent income and mortality data.

MATERIALS AND METHODS

We followed the five steps undertaken in the original work to develop the revised version of the index (Swiss-SEP 2) [3]: (1) define neighbourhoods of around 50 households, (2) characterize these neighbourhoods socioeconomically, (3) develop the index, (4) examine the index's construct validity using independent income data, and (5) examine mortality by index levels. Full details of the data preparation steps, the exclusion and inclusion criteria and the size of datasets are provided in Supplementary Materials.

Definition of neighbourhoods

As in developing the original index, we used all residential buildings in Switzerland as centres of neighbourhoods. We then collected the data from four annual waves of the micro censuses from 2012 to 2015. We decided against using data from 2010 and 2011, the two first micro censuses, due to data quality issues and missing information. The combined dataset from the four micro censuses allowed us to replicate the original procedure for defining and characterizing neighbourhoods. Naturally, using a sample of individuals and their households instead of a complete census meant that the geographical size of areas had to be enlarged to include still the 50 closest homes included in the surveys.

Socioeconomic standing of neighbourhoods

We used the same four domains that were the basis of the original index to describe neighbourhoods. Housing and income domains remained unchanged, based on the rent per square metre in three- to five-room flats, and crowding defined as the mean number of persons per room, counting bed and living rooms [3]. The micro census did not specify the head of the household. Instead, the information on the adult respondent was used. In addition, the original categorization of occupations developed by the Swiss Federal Statistical Office was no longer available for all survey years. Therefore, we used the International Standard Classification of Occupations data to categorize occupations [11].

Construction and combination of indexes

As for the previous index version, we used principal component analysis on neighbourhood aggregated indicators to construct Swiss-SEP 2. We combined the loadings of the first principal component to obtain a value for the socioeconomic position of a neighbourhood. Higher values represented neighbourhoods of higher socioeconomic position. The analysis was weighted by the number of households to account for differences in area size and standardized to a range of 0 to 100. In addition to the new index, we also created a hybrid version of the index (Swiss-SEP 3), which included updated values for new neighbourhoods around buildings built after 2000 and the original values for the remaining areas.

Validation using household panel data

We re-examined the construct validity of the new Swiss-SEP 2 and hybrid Swiss-SEP 3 indices by exploring their association with income data collected by the Swiss Household Panel, a longitudinal study following a random sample of Swiss households [12]. We included the participants from recruitment waves 1999, 2004, and 2013 and geocoded the residences of 7,252 (98.6%) households that participated in one or several waves and completed the questionnaire in 2014. The geocoding was based on Swiss federal register of buildings and dwellings [13]. We used the same variables as in the original study [3], i.e. self-reported equivalised yearly household income in Swiss francs (CHF), and again calculated the yearly mean equivalised household income, which adjusts for family size [14]. Information about equivalised income was available for 7,193 [99.1%; imputed for 588 (8.1%)] households. In further analyses, we examined data on expenses, contributions to tax-free private pension schemes and reception of financial help.

Mortality across deciles of indices

Finally, we updated all-cause and cause-specific mortality analyses [3]. We examined mortality from lung cancer (ICD-10 codes C33-C34), breast cancer (ICD-10 code C50), prostate cancer (ICD-10 code C61), respiratory diseases (ICD-10 codes J00-J99), cardiovascular diseases (ICD-10 codes I00-I99), myocardial infarction (ICD-10 codes I21-I22), stroke (ICD-10 codes I60-I64), traffic accidents (ICD-10 codes V01-V99) and suicide (ICD-10 codes X60-X84). The updated analysis was based on 304,162 deaths recorded from 2012 to 2018 among 5.25 million individuals aged 30 years or older. We used Cox proportional hazard regression to compare mortality by deciles of the three versions of the Swiss-SEP index. We measured time from January 1, 2012, to the earliest of death, emigration or December 31 2018. Models were adjusted for age (by using age as the time scale) and sex to compare them with the previous analyses. Fully adjusted analyses were no longer possible due to a lack of individual-level education and professional status information. In supplementary materials, we present models adjusted for age, sex, nationality, civil status, language region and level of urbanization of place of residence. Results are presented as hazard ratios with 95% confidence intervals (CI).

We did all analyses in Stata (version 15, Stata Corporation, College Station, TX, USA), R (version 4.2.0, R Foundation for Statistical Computing, Vienna, Austria) and ArcGIS (version 10.5, Environmental Systems Research Institute, Redlands, CA, USA) software. The study was performed within the framework of the Swiss National Cohort, with ethics approval from the Ethics Committee of the Canton Bern (No. 153/2014).

RESULTS

Analyses were based on 1.54 million neighbourhoods, with 892,127 households included in the micro censuses. The mean size of overlapping neighbourhoods was 50.5 households (SD 1.31) and 131 individuals (SD 16.0), similar to the old index [3]. Compared to the old index [3], the median of the mean distance by road between the reference building and the other buildings within the neighbourhood of around 50 households increased substantially, from 131 m to 272 m for the new index.

The first principal component retained to construct the index explained 48.9% of the total variance with similar loadings to those obtained previously [3]. The hybrid version of the index (Swiss-SEP 3) retained values of the original index for 1.31 million neighbourhoods. It updated the values for 235,161 (15.3%) areas centred on buildings constructed after 2000 (see Supplementary Materials for further details).

As expected, the two variables used in constructing the index – educational and professional status showed a steep gradient across the index deciles (**Table 1**; using Swiss-SEP 3). For instance, the proportion of individuals with primary education or less was four and half times higher in the neighbourhoods of decile 1 than in decile 10. On the other hand, the highest professional category of employment was nearly four times less prevalent. Variables not used in the construction of the index directly but also connected to socioeconomic position also varied – for instance proportion of foreign residents in the neighbourhood decreased from 31.8% to 18.3% from decile 1 to decile 10. These results were similar across the other versions of the index (see Supplementary Materials) and resembled findings from the original work [3]. Also, the spatial distribution of the new (Swiss-SEP 2) and hybrid (Swiss-SEP 3) indices largely followed the original study's findings (**Figure 1**). Neighbourhoods of higher SEP continued to be concentrated around the urban centres of Basel, Bern, Geneva, Lausanne and Zurich and their surroundings and along Lake Lemman and both sides of Lake Zurich. The areas of lower SEP were concentrated in rural areas of the northeast and central Switzerland, in the arc of the Jura and most of the Alpine valleys.

All three versions of the Swiss-SEP index correlated well with the yearly equivalised household income from the Swiss Household Panel (**Figure 2**). For instance, the median income in 2013 for the analysis of the hybrid index rose from 55,000 Swiss Francs (CHF) among households in the 1st Swiss-SEP decile to 88,000 CHF in the 10th decile. The corresponding range in the previous analysis was slightly less extreme (from 42,000 CHF to 72,000 CHF). The other financial characteristics analysed were closely similar to the original analysis [3] (see Supplementary Materials).

Mortality analyses were based on 33.6 million person-years of follow-up. Both old and updated Swiss-SEP indices were associated with all-cause mortality and cause-specific mortality. The age- and sex-adjusted hazard ratios of all-cause mortality comparing areas in the lowest decile of the Swiss-SEP with areas in the highest decile were 1.39 (95% CI 1.36-1.41), 1.31 (95% CI 1.29-

1.33) and 1.34 (95% CI 1.32-1.37) using Swiss-SEP 1, Swiss-SEP 2 or Swiss-SEP 3 indices, respectively. There was a clear gradient across deciles (**Figure 3**). Slightly stronger associations were observed in the fully adjusted models. In the cause-specific mortality analyses, markedly stronger associations in the same direction were observed for lung cancer, respiratory diseases and traffic accidents (**Table 2**). There was little evidence for an association with breast cancer mortality. Of note, the association of the new index tended to be slightly weaker than the association with either the old or hybrid index. Estimates based on the old index were similar for the earlier (2001-2008) and later (2012-2018) periods, except for suicide. In the earlier period, suicide was less common in areas with higher socioeconomic status, while in the later period, suicide was more common in these areas.

DISCUSSION

We updated the Swiss-SEP index, an area-based index of socioeconomic position widely used in Switzerland. We developed a new version of the index based on the micro census data with reduced spatial resolution. A hybrid version uses the original index values for buildings constructed up to 2000 and new values for buildings constructed since then. An update was deemed necessary because the old version of the index was based on census data collected in 2000, more than 20 years ago. It was complicated by the fact that Switzerland, like several other European countries, changed from a complete, house-to-house census every ten years to an administrative register-based census combined with annual surveys (micro censuses) of about 200,000 persons at the 2011 census round [15].

Here, we demonstrate the feasibility of creating a new index using a more limited amount of information than what was available in the 2000 national house-to-house census. All three versions of the index had construct validity, with household income increasing with higher socioeconomic position. Further, there was a gradient across Swiss-SEP index deciles for all-cause and mortality from several specific causes, independently of the version of the index used, old, new, or hybrid.

The new index uses more recent data from the micro censuses; the disadvantage is the lower resolution than the old index. In our previous analysis [3], we repeated analyses using mean values of the index for local authorities and urban districts, i.e. much larger areas. As expected, the association with mortality became considerably weaker. A trend in this direction could also be observed in the present study when using the new index. However, differences were small, and confidence intervals overlapped widely. Among the different dimensions of socioeconomic position, income appears to be most strongly associated with health, particularly health in older age [16]. Interestingly, in our evaluation of construct validity, the association of the Swiss-SEP index with independent household income data from a panel study was similar for the old, new and hybrid indices [3].

Which index should be used today in Switzerland for research on the importance of the socioeconomic environment on health outcomes, or research with another focus aiming to adjust for the socioeconomic position? Our results indicate that the socioeconomic position of neighbourhoods in Switzerland have changed relatively little in the past 20 years, at least in relative terms. However, it is clear that the population has increased, and new buildings and neighbourhoods have sprung up. Therefore, using the hybrid version of the index (Swiss-SEP 3) seems to be a reasonable choice, preserving the original index's higher resolution while accommodating new neighbourhoods. In recent years, few high-resolution area-based datasets relevant to socioeconomic position have become available in Switzerland. Commercially available, but to our knowledge, unvalidated data on purchasing power have become available, but only at a high level of aggregation, at the level of municipalities [17]. Alternative data sources such as detailed data on car ownership [18], mobile phone [19] or social media data [20] or data on specific environmental exposures from high-resolution satellite images [21] might offer opportunities in the future. Finally, the availability of yearly micro censuses allows updating indices more frequently with new data while also improving resolution [22].

The new versions of Swiss-SEP inherited the limitations inherent in the original work. Switzerland still does not have access to any high resolution and high coverage data about income at the individual level. Such data are inherently difficult to obtain in the Swiss context, where information on income is highly sensitive. In the absence of access to other data sources on income, rent remains the only viable alternative. To combine indices, we continued to rely on principal component analysis for creating the index. Other methods are available, but there is no consensus on best practices or guidelines for developing such indices [23].

In conclusion, despite the sparser data, we demonstrated the feasibility of updating the Swiss-SEP within the new micro census system adopted by Switzerland in 2020. The three versions of the area-based Swiss-SEP index appear to be similarly valid. The hybrid version maintains the high spatial resolution of the old version while adding information on new neighbourhoods around buildings constructed since 2000. The family of Swiss-SEP indices will continue to support research on socioeconomic position and health whenever data on individual-level socioeconomic status are missing or the contextual effect of area-based socioeconomic position of interest. We will make all three versions of the Swiss-SEP index available to interested researchers on a dedicated website.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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CONTRIBUTORSHIP STATEMENT

RP, MZ & ME conceived the study. RP, MZ & ME drafted the first version of the manuscript. RP & CB did all data management and RP & MZ did all statistical analyses. All authors contributed to the interpretation of data and read and approved the final manuscript.

DATA ACCESS

The data are the property of the Swiss Federal Statistical Office (SFSO) and can only be made available by legal agreements with the SFSO. After approval of the SNC Scientific Board, a contract with the SFSO allows researchers to receive analysis files for replication of the analysis. Access to the final dataset of the Swiss-SEP is possible after signing a contract with the SNC. Interested researchers, please contact the SNC directly via snc_info@ispm.unibe.ch.

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TABLES

Table 1. Characteristics of the sample of the resident population in Switzerland across the first (lowest SEP), fifth and tenth (highest SEP) decile of the hybrid version of the Swiss neighbourhood index of Socio-Economic Position (Swiss-SEP 3), Switzerland.

Characteristic		Index decile			Total
		1	5	10	
		N (%)	N (%)	N (%)	N (%)
Gender	Male	49782 (48.6)	41660 (47.3)	36229 (47.3)	424130 (47.5)
	Female	52601 (51.4)	46325 (52.7)	40309 (52.7)	467997 (52.5)
Age	19-34	26569 (26.0)	20018 (22.8)	13510 (17.7)	200604 (22.5)
	35-49	30416 (29.7)	25099 (28.5)	21905 (28.6)	255462 (28.6)
	50-64	25016 (24.4)	22338 (25.4)	20522 (26.8)	228477 (25.6)
	Above 65	20382 (19.9)	20530 (23.3)	20601 (26.9)	207584 (23.3)
	Single	25912 (25.3)	23574 (26.8)	19571 (25.6)	235941 (26.4)
	Married	60671 (59.3)	50077 (56.9)	46283 (60.5)	517255 (58.0)
Civil status	Widowed	6156 (6.0)	5561 (6.3)	4120 (5.4)	53453 (6.0)
	Divorced	9643 (9.4)	8773 (10.0)	6564 (8.6)	85477 (9.6)
	(Missing)	1 (0.0)	0 (0.0)	0 (0.0)	1 (0.0)
	Swiss	69874 (68.2)	70681 (80.3)	62514 (81.7)	703676 (78.9)
Nationality	Foreigner	32509 (31.8)	17304 (19.7)	14024 (18.3)	188451 (21.1)
	German	40613 (39.7)	52825 (60.0)	53580 (70.0)	518985 (58.2)
Language	French	34020 (33.2)	20684 (23.5)	15712 (20.5)	226063 (25.3)
	Italian	12614 (12.3)	7659 (8.7)	1355 (1.8)	69155 (7.8)
	Other	15136 (14.8)	6817 (7.7)	5891 (7.7)	77924 (8.7)
	Primary education or less	37232 (36.4)	18745 (21.3)	6134 (8.0)	188309 (21.1)
	Upper secondary level	46845 (45.8)	45382 (51.6)	31333 (40.9)	434965 (48.8)
Education	Tertiary level	18306 (17.9)	23858 (27.1)	39071 (51.0)	268853 (30.1)
	Top management and independent professions	1320 (1.3)	1582 (1.8)	3833 (5.0)	20548 (2.3)
Professional status	Other self-employed	3480 (3.4)	2872 (3.3)	2491 (3.3)	29047 (3.3)
	Professionals and senior management	3599 (3.5)	5233 (5.9)	9250 (12.1)	60297 (6.8)
	Supervisors/low level management and skilled labour	24398 (23.8)	23411 (26.6)	15025 (19.6)	223131 (25.0)
	Unskilled employees and workers	7165 (7.0)	3000 (3.4)	749 (1.0)	31914 (3.6)
	In paid employment, not classified elsewhere	4005 (3.9)	2648 (3.0)	1545 (2.0)	26426 (3.0)
	Unemployed/job-seeking	3319 (3.2)	1981 (2.3)	1293 (1.7)	20377 (2.3)
	Not in paid employment	25702 (25.1)	22239 (25.3)	20098 (26.3)	225064 (25.2)
	(Missing)	29395 (28.7)	25019 (28.4)	22254 (29.1)	255323 (28.6)
	Urban	27683 (27.0)	22694 (25.8)	26015 (34.0)	249565 (28.0)
	Peri-urban	30417 (29.7)	39056 (44.4)	49218 (64.3)	408700 (45.8)
Level of urbanisation	Rural	44283 (43.3)	26235 (29.8)	1305 (1.7)	233862 (26.2)

Source: micro censuses 2012 - 2015. The professional status categories shown are those used for the construction of the original Swiss-SEP 1. For Swiss-SEP 2, the International Standard Classification of Occupations (ISCO) was used.

Table 2. Hazard ratios of death from all causes and selected causes in the Swiss resident population comparing the first decile (lowest SEP) of different versions of the Swiss neighbourhood index of Socio-Economic Position (Swiss-SEP) to the tenth decile (highest SEP). Source: Swiss National Cohort, 2001-2008 [3] and 2012-2018.

	Previous analysis (2001-2008)		Updated analysis (2012-2018)	
	Swiss-SEP 1	Swiss-SEP 1	Swiss-SEP 2	Swiss-SEP 3
All causes	1.38 (1.36-1.41)	1.39 (1.36-1.41)	1.31 (1.29-1.33)	1.34 (1.32-1.37)
Lung cancer	1.83 (1.71-1.95)	1.93 (1.79-2.08)	1.79 (1.67-1.92)	1.82 (1.69-1.96)
Breast cancer	0.93 (0.85-1.02)	1.09 (0.97-1.22)	1.01 (0.91-1.13)	1.04 (0.93-1.17)
Prostate cancer	1.17 (1.07-1.28)	1.15 (1.03-1.29)	1.13 (1.02-1.26)	1.14 (1.02-1.27)
Cardiovascular disease	1.48 (1.44-1.51)	1.49 (1.44-1.54)	1.38 (1.34-1.43)	1.44 (1.39-1.49)
Myocardial infarction	1.68 (1.57-1.80)	1.64 (1.48-1.80)	1.53 (1.40-1.67)	1.55 (1.41-1.70)
Stroke	1.28 (1.20-1.36)	1.25 (1.14-1.36)	1.25 (1.15-1.35)	1.22 (1.12-1.33)
Respiratory disease	1.99 (1.87-2.12)	1.81 (1.68-1.94)	1.63 (1.53-1.74)	1.72 (1.60-1.85)
Traffic accidents	2.42 (1.94-3.01)	1.80 (1.36-2.39)	2.13 (1.59-2.86)	1.89 (1.43-2.51)
Suicide	0.86 (0.78-0.95)	1.32 (1.14-1.51)	1.31 (1.15-1.49)	1.29 (1.12-1.48)

Results from age- and sex-adjusted models.

FIGURES

Figure 1. Map of the new (Swiss-SEP 2) and hybrid (Swiss-SEP 3) indices. The original values of 1.54 million neighbourhoods were aggregated into a hexagonal grid with a cell size of 500m to improve the figure's clarity. Each grid displays the median value of index deciles.

Figure 2. Box plots of the distribution of equivalised yearly household income across deciles of three indices. Data from 7,193 Swiss Household Panel participants that provided information or had imputed information on the income questions in 2014. Boxplots exclude outliers for better visibility of the central distribution. See Supplementary Files 2 & 3 for more details.

Figure 3. Hazard ratios of all-cause mortality across deciles of the three versions of the Swiss-SEP indices.

Analyses based on Swiss National Cohort data on 304,000 deaths between 2012 and 2018 among 5.25 million individuals aged 30 or older. Fully adjusted analyses included age, sex, nationality, civil status, language region and level of urbanization. Group "10" (highest SEP index) on the Y-axis is the reference group for all models.