# A new reliable index to measure individual deprivation: the EPICES score

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**Background:** Deprivation is associated with inequalities in health care and higher morbidity and mortality. To assess the reliability of a new individual deprivation score, the EPICES score and to analyse the association between the Townsend index, the Carstairs index and the EPICES score and causes of death in one French administrative region. **Methods:** Eligible patients were 16 years old or more who had come for consultation in Health Examination Centres of the French administrative region of Nord-Pas-de-Calais. An ecological study was performed between 2002 and 2007 in the 392 districts of this administrative region. The EPICES score was compared with the Townsend and the Carstairs indices. These three measurements of deprivation were compared with social characteristics, indicators of morbidity, health-care use and mortality and specific causes of death. The Pearson correlation coefficients were calculated to assess the reliability of the EPICES score. The association between deprivation and mortality was assessed by comparison of the standardized mortality ratio (SMR) between the most and least deprived districts. **Results:** The EPICES score was strongly correlated with the Townsend and Carstairs indices and with the health indicators measured. SMR increased with deprivation and the higher the deprivation the higher the SMR for all-cause mortality, premature and avoidable deaths and for most specific causes of death. **Conclusion:** The individual deprivation EPICES score is reliable. Deprivation was related to excess death rate, which clearly indicates that deprivation is a determinant factor that should be considered systematically by health policy makers and health-care providers.

## Introduction

Deprivation was defined by J. Wrezinski as 'the lack of safety, like a job, enabling individuals and families to assume professional, family and social responsibilities and to enjoy basic rights'. He then went on to describe the process that transforms temporarily deprived situations to such an extent that they become permanent and affect several areas of an individuals' life and lead to extreme poverty.[1] At the same time, P. Townsend defined the concept of deprivation as a 'state of observable and demonstrable disadvantage relative to the local community or the wider society to which an individual, family or group belongs'. He applied this concept to conditions rather than resources and made a distinction between deprivation and poverty.[2] He also reported that deprivation is the main cause of inequalities in health, and developed an index to measure deprivation over a given geographic area.[3]

In France, 112 preventive Health Examination Centres (HEC) provide medical consultations to recipients of the national health insurance for salaried workers and their family. Patients do not pay and can consult without being referred. In 1992, a ministerial order designated who should have priority for these consultations, such as retirees, job seekers, young people just entering the job market, the homeless and persons exposed to risk factors for health.[4] These people account for a third of all those annually cared for by the HECs. In 2002, the HECs developed an individual index of deprivation, called the EPICES (*Evaluation de la Précarité et des Inégalités de santé dans les Centres d'Examens de Santé - Evaluation of Deprivation and Inequalities in Health Examination Centres*), to improve the screening of deprived patients and their subsequent health management and quality of care.

The main aim of this study was to assess the reliability of the EPICES score by comparing it with the two main indices of deprivation, the Townsend Index and the Carstairs Index and by comparing the correlation of these three scores with social characteristics, indicators of morbidity, health-care use and mortality. The secondary objective was to analyse the association between the three deprivation measurements and the causes of death in one French administrative region.

## Patients and method

### Patients

The eligible patients were aged 16 years old or more and were screened in one of the seven HECs in the administrative region of 'Nord-Pas-de-Calais', northern France. All patients screened had an anonymous computerized medical record that was used for the study.

### Methods

An ecological study was performed in one administrative region made of 392 districts between January 2002 and December 2007.

In France, the smallest unit of local government is the commune, then there are the districts corresponding in one or several communes and the biggest unit is the administrative region corresponding in several districts. A district is identified by one postcode.

During screening consultations performed in HECs, a record is made of demographic, social, economic and medical data, the EPICES score and any preventive procedures. Deprivation was calculated by three validated indices, the EPICES score, the Townsend and the Carstairs indices. The EPICES score was measured per patient and EPICES score means were calculated per districts using patients' postcode. The indices of Townsend and Carstairs were computed by district on data extracted from the 2006 census.

The EPICES score was developed in 2002 and was based on a first questionnaire of 42 items selected by a panel of French experts from National Health Insurance relative to dimensions of deprivation as defined by Wrezinski and Townsend.[1,2] A factorial correspondence analysis identified 11 salient items on which calculation of the EPICES score is based: marital status (one item), health insurance status (one item), economic status (three items), family support (three items) and leisure activity (three items; Supplementary Appendix S1). The score is computed by adding each question co-efficient to intercept whenever the answer is 'yes'. The higher the score, the more deprived the patient is. It was validated on a cohort of 197 389 persons.[5] The Townsend and the Carstairs indices were chosen because they were the two best and well-known indices to measure deprivation.[6] The Townsend index is generated as the sum of four standardized variables without weighting: unemployment rate among persons who are economically active, the percentage of non-car ownership among all households, the percentage of non-home ownership among all households and household overcrowding.[2] The higher the score, the more deprived the area is. The Carstairs index, here based on the unweighted addition of four standardized variables: unemployment rate among men aged 16 and over who are economically active, the percentage of non-car ownership among all households, household overcrowding and an economically active head of household in a deprived situation.[7] The higher the score, the more deprived the area is. The level of education was the only individual characteristic used because it was identified in previous studies as being the most significant[5,8] Four items were used to measure morbidity: smoking status, obesity, poor self-perceived health and one or more tooth cavities.[5,8] Obesity was defined by a body mass index greater than 30 kg/m$^2$. Poor self-perceived health was defined by a score lower than 7 on a 10-point grade scale, from the worst self-perception of health (0) to the best self-perception of health (10). Three indicators were measured to assess health-care use: no consultation with General Practitioners, no dental care and no gynaecological follow-up during the previous 2 years.

Mortality data between 2004 and 2007 were extracted and computed to calculate death rates by district. Data on number and causes of death were provided by the French National Institute of Health and Medical Research (INSERM) from the records of the Department of Epidemiology on Medical Causes of Death (Cepidc). Causes of death were classified according to the tenth International Classification of Diseases {ICD10}.[9] Data used for analyses were: all causes of death, death due to diseases of the circulatory system (all cardiovascular diseases {I00-I99}, ischaemic heart diseases {I20-I25}, cerebrovascular diseases {I60-I69}, diseases of the respiratory system {J00-J99}, diabetes mellitus {E10-E14}, chronic liver diseases (alcoholic liver disease {K70}, chronic hepatitis {K73} and fibrosis and cirrhosis of the liver {K74}), mental and behavioural disorders due to use of alcohol {F10}, external causes of morbidity and mortality (transport accidents {V01-V99} and intentional self-harm {X60-X84}) and malignant neoplasms (all {C00-C97} and per organ: lip, oral cavity and, pharynx {C00-C14}, oesophagus {C15}, stomach {C16} and colon {C18}, larynx {C32}, trachea {C33}, bronchus and lung {C34}, breast {C50} and cervix {C53}). Premature mortality, as defined by deaths occurring before the age of 65 years, and avoidable mortality, as defined by premature deaths for which effective preventive care and medical interventions were available, were also analysed.

## Statistical analysis

The reliability of the EPICES score was measured by computing correlations between the EPICES score, the Townsend index and the Carstairs index, and between the respective measurements of deprivation and morbidity, health-care use and all causes of death between 2004 and 2007 by district. Pearson correlation coefficients were measured and results were weighted by population to take into account the effect of less inhabited districts.

To measure the association between the three measurements of deprivation and mortality, deprivation scores were ranked by quintile from the first quintile (Q1), corresponding to the least deprived districts, to the fifth quintile (Q5) for those most deprived. Standardized mortality ratio (SMR) and its 95% confident interval (95%CI) were calculated for all causes of death, premature mortality, avoidable mortality and cause of death in both men and women, by quintile. SMR was the ratio between observed mortality and expected mortality when the sex and age of the population are taken into account. Observed mortality was the actual number of death among the surveyed population. Expected mortality was calculated by applying the French national mortality rate to the surveyed population. With SMR equal to 100, there is no difference between the two populations compared. If SMR is greater than 100 there is an excess death rate compared to the French national population. In addition, a ratio between SMR-Q5 and SMR-Q1 was calculated to measure the extent of the gap. To simplify the article, we presented only significant results of deprivations scores Q1 (less deprived) and Q5 (most deprived). A meaningful threshold of 5% was chosen for all statistical analyses which were performed on SPSS V15 software.

## Results

Of the 4 021 676 inhabitants of Nord-Pas-de-Calais, 183 670 persons were included in the study: 89 928 men (48.96%) and 93 742 women (51.04%). Of the 141 366 deaths occurring between 2004 and 2007 [73 461 (51.97%) and 67 905 (48.03%) for men and women respectively], 36 107 were premature deaths [25 150 (69.65%) and 10 957 (30.35%) for men and women, respectively]. Postcodes identified 392 districts.

The EPICES score was strongly correlated with the Townsend and Carstairs indices and with health measures except for premature death in women (Table 1). In the whole, the EPICES score performed as well as the Carstairs and Townsend indices (fig. 1).

Data concerning all-cause mortality showed excess death rates as of the first quintile (Q1) increasing between Q1 and Q5 in both men and women with a significantly higher SMR for the most deprived districts. Excess mortality rates for premature and avoidable deaths were observed for the most deprived districts only, irrespective of sex. Premature mortality in the most deprived districts exceeded national mortality rates, from 63 to 65% for men and from 48 to 50% for women (Tables 2 and 3). The SMRs for specific cause of death increased with the deprivation and the higher the deprivation, the higher the SMR, except for transport accidents and stomach cancer in men and women. Excess death rates were recorded in the most deprived districts only for mental and behavioural disorders due to alcohol, diabetes, suicide in both men and women and for malignant neoplasm of the colon in men. The highest SMR ratio was observed for mental and behavioural disorders due to alcohol, with twice as many deaths in the most deprived districts for both men and women. All results were congruent between the three deprivation indices, with the EPICES score yielding different results from the other indices in only 2 cases

**Table 1** Measurement of the correlation between the EPICES score, the Townsend and the Carstairs indices and the correlation between those three deprivation indices and indicators of morbidity, health care use and mortality

| Deprivation indices | Deprivation indices | | |
| --- | --- | --- | --- |
| | EPICES | Townsend | Carstairs |
| EPICES | – | 0.81* | 0.84* |
| Townsend | | – | 0.95* |
| Carstairs | | | – |
| *Social characteristic* | | | |
| Level of education: no graduation/illiterate | 0.79* | 0.58* | 0.68* |
| *Indicators of morbidity* | | | |
| Smoking status: current smokers | 0.71* | 0.59* | 0.62* |
| Obesity (BMI > 30 kg/m$^2$) | 0.58* | 0.36* | 0.47* |
| Poor-self perceived health | 0.79* | 0.56* | 0.63* |
| At least one tooth decay | 0.72* | 0.64* | 0.66* |
| *Indicators of health care use* | | | |
| No consultation with GPs during the last two years | 0.55* | 0.50* | 0.50* |
| No dental care during the last two years | 0.73* | 0.53* | 0.61* |
| No gynaecological follow-up during the last two years | 0.64* | 0.60* | 0.66* |
| *Indicators of mortality* | | | |
| All causes of death for men (SMR) | 0.58* | 0.60* | 0.63* |
| Premature death for men (SMR) | 0.64* | 0.65* | 0.66* |
| All causes of death for women (SMR) | 0.36* | 0.26* | 0.34* |
| Premature death for women (SMR) | 0.39* | 0.47* | 0.45* |

*$P < 10^{-5}$

EPICES, Evaluation of Deprivation and Inequalities in Health Examination Centres; BMI, Body Mass Index; GPs, General Practitioners; SMR, standardized mortality ratio = mortality observed in the administrative region of Nord-Pas-de-Calais/ expected mortality calculated by applying national death rate

out of 27: stomach cancer in women for which there was no difference according to EPICES score, and cervix cancer, for which, in contrast to the other two indices, EPICES score did produce differences (Supplementary Appendices S2 and S3).

# Discussion

## Main results

In the study of a French administrative region, the individual EPICES deprivation score yielded comparable results to those of the Townsend and Carstairs indices. Social deprivation and material deprivation can, therefore, be measured by a single index at both individual and geographical levels. Deprivation was linked to an excess death rate in all causes of death, premature death, avoidable death and in most of specific causes of death. These results show that deprivation is a factor that should be considered systematically by health policy makers and health-care providers, in particular in primary health care.

## Comparisons with other studies

One study has already demonstrated that the EPICES score is a more robust index to measure deprivation than that given in the French health ministry order published 20 July 1992.[4,10] This study showed not only the better association between deprivation as measured by the EPICES score and social and health indicators but also that the score was able to identify the deprived people not considered as such by the administrative definition. In addition, other studies have shown that the EPICES score is an independent determinant of worse health status.[11,12] It was observed that the higher the EPICES score, the worse

was the patient's concentration of glycated haemoglobin and the more frequent the complications of neuropathy and retinopathy.[11] Moulin et al.[12] demonstrated that deprivation measured by the EPICES score was related to disease risk factors such as smoking, excessive alcohol consumption, obesity and low physical activity, and to factors of health-care use like consultations with a gynaecologist and medical follow-up. The results of our study are neither surprising nor unexpected. Like those of several studies performed in the United States, Great Britain, France and other European countries, they clearly show an association between deprivation and higher morbidity and mortality.[7,13–27]

## Strengths and limitations

Despite being one administrative region-based study, this work was performed in 392 districts that provided a large sample population. However, this region has not only the second higher percentage of person under the poverty threshold (25.7 vs. 18.9% in France) but also the lowest life expectancy, and one of the highest death rates for avoidable mortality and for mortality by cancer in France.[28,29] Hence, our results may be underestimated because SMR in Q1 was higher than in any other French administrative regions and could not be extrapolated without further research. It would be interesting, therefore, to perform additional studies in different French regions and in different countries to have a more accurate assessment of the relation between the EPICES score and SMR. In addition, because data concerning the EPICES score and the Townsend and Carstairs indices and death rates were collected at different periods, our results could have been influenced by a time effect. However, the impact of such an effect over a short period would only be very limited as we mainly worked on mortality data, which change very slowly over time. In addition, our aim was not to measure changes in deprivation and health indicators at two different time periods with the result that our study is not limited by changes in deprivation and in boundaries of the administrative region studied, a drawback pointed out by Exeter et al. and Norman et al.[30–32] Our results were congruent whatever the indicator used and so it is unlikely that a time effect was detrimental to the findings of the study which was based on data collected from fragmented geographic districts. It would be interesting to perform spatial mixed models to study deprivation and its effects on health indicators across a continuous space.[33] Correlation method was used instead of agreement (as developed by Bland and Altman) because deprivation was not expressed with the same units of measurement.[34,35]

To our knowledge, this study is the first to simultaneously analyse individual deprivation scores and geographic deprivation indices.

## Improvement proposals

Unlike geographical indices, the EPICES score allows analysis at an individual level and can be aggregated to perform an ecological analysis at an appropriate level corresponding to 'the geographic unit as small as possible and as homogenous as possible in its socioeconomic characteristics' as established by Pampalon and Raymond.[36] This kind of ecological analysis, which takes into account individual characteristics and the context of the environment that Chauvin named 'the ecological bias', avoids concluding wrongly that an area is deprived.[37] A spatial mixed model could also be a more suitable analysis, to not only avoid this bias but also to consider environmental characteristics. The effect of local area features on people's health has already been shown by several studies.[33,38–40] In addition, as the EPICES score is more effective in measuring deprivation than the present socio-administrative definition,[10] it could serve as an additional means to accurately identify which persons are deprived and to adapt health management to life conditions.
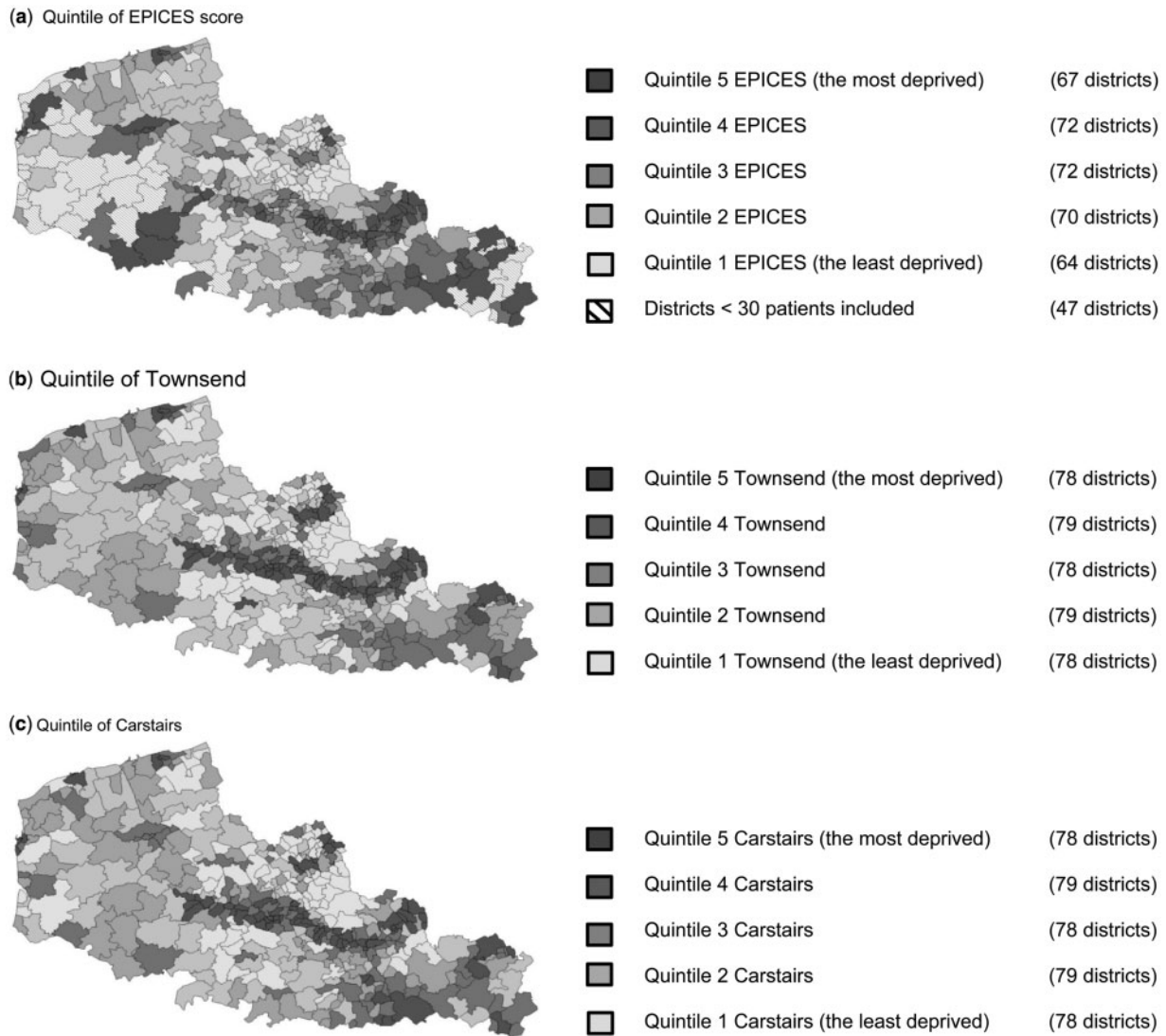
**Figure 1** Quintiles of deprivation for EPICES score (a), Townsend index (b) and Carstairs index (c) in the 392 districts of the administrative region of 'Nord-Pas-de-Calais'

**Table 2** SMR of the least deprived and most deprived districts per deprivation index for all causes, premature and avoidable death for men in the administrative region of 'Nord-Pas-de-Calais'

| Causes of death [ICD] | Number of deaths | | EPICES score SMR [95%CI] | Townsend index SMR [95%CI] | Carstairs index SMR [95%CI] |
|---|---|---|---|---|---|
| All causes [A00-Y89] | 73 461 | $SMR_{Q5}$ | 143.12 [141.16–145.11] | 141.75 [140.15–143.37] | 144.49 [142.74–146.26] |
| | | $SMR_{Q1}$ | 111.88 [109.30–114.51] | 109.37 [106.85–111.93] | 107.07 [104.88–109.29] |
| | | Ratio | 1.28* | 1.30* | 1.35* |
| Premature death [A00-Y89] | 25 150 | $SMR_{Q5}$ | 165.76 [161.98–169.60] | 163.26 [160.23–166.34] | 165.77 [162.47–169.13] |
| | | $SMR_{Q1}$ | 102.53 [98.33–106.87] | 97.33 [93.33–101.45] | 97.56 [93.97–101.25] |
| | | Ratio | 1.62* | 1.68* | 1.70* |
| Avoidable death by improving access to health care [A15-A19] [B90] [C43] [C50] [C53] [C81] [C90-97] [I05-10] [I20-25] [I60-69] [J10] [J45] [K00-93] | 2755 | $SMR_{Q5}$ | 164.09 [152.82–175.96] | 161.88 [152.77–171.39] | 162.55 [152.69–172.88] |
| | | $SMR_{Q1S}$ | 103.91 [91.54–117.47] | 104.59 [92.48–117.84] | 104.31 [93.44–116.1] |
| | | Ratio | 1.58* | 1.55* | 1.56* |
| Avoidable death by reducing individual risk factors [B20-B24, C00-C14, C32-C34,F10, K70, K73-K74, V01-V99, W00-W19, X60-X84] | 10 275 | $SMR_{Q5}$ | 175.99 [169.71–182.45] | 171.96 [166.95–177.09] | 176.36 [170.87–181.98] |
| | | $SMR_{Q1}$ | 108.67 [101.71–116] | 102.70 [96.1–109.64]S | 103.26 [97.31–109.48] |
| | | Ratio | 1.62* | 1.67* | 1.71* |

*Ratio is significant at a meaningful threshold of 5%
ICD, International Classification of diseases; SMR, standardized mortality ratio based on French national mortality rates; Q1, first quintile, the least deprived; Q5, fifth quintile, the most deprived; 95%CI, 95% Confident Interval

**Table 3** SMR of the least deprived and most deprived districts per deprivation index for all causes, premature and avoidable death for women in the administrative region of 'Nord-Pas-de-Calais'

| Causes of death [ICD] | Number of deaths | | EPICES score SMR [95%CI] | Townsend index SMR [95%CI] | Carstairs index SMR [95%CI] |
|---|---|---|---|---|---|
| All causes [A00-Y89] | 67 905 | $SMR_{Q5}$ | 127.89 [126.00–129.80] | 125.40 [123.93–126.87] | 127.06 [125.46–128.68] |
| | | $SMR_{Q1}$ | 112.69 [110.01–115.41] | 113.19 [110.44–116.00] | 110.91 [108.57–113.29] |
| | | Ratio | 1.13* | 1.11* | 1.15* |
| Premature death [A00-Y89] | 10 957 | $SMR_{Q5}$ | 148.28 [142.88–153.84] | 149.40 [145.22–153.67] | 150.14 [145.60–154.79] |
| | | $SMR_{Q1}$ | 100.36 [94.34–106.66] | 98.75 [92.78–105.01] | 100.63 [95.27–106.22] |
| | | Ratio | 1.48* | 1.51* | 1.49* |
| Avoidable death by improving access to health care [A15-A19] [B90] [C43] [C50] [C53] [C81] [C90-97] [I05-10] [I20-25] [I60-69] [J10] [J45] [K00-93] | 2673 | $SMR_{Q5}$ | 148.54 [137.49–160.24] | 145.57 [137.08–154.44] | 143.99 [134.84–153.59] |
| | | $SMR_{Q1}$ | 113.82 [100.96–127.86] | 103.42 [91.16–116.87] | 107.53 [96.39–119.61] |
| | | Ratio | 1.31* | 1.41* | 1.34* |
| Avoidable death by reducing individual risk factors [B20-B24,C00-C14,C32-C34, F10, K70, K73-K74, V01-V99, W00-W19, X60-X84] | 2820 | $SMR_{Q5}$ | 167.67 [155.98–180.00] | 166.69 [157.73–176.03] | 169.68 [159.88–179.91] |
| | | $SMR_{Q1}$ | 94.26 [82.55–107.18] | 94.50 [82.75–107.45] | 101.45 [90.59–113.26] |
| | | Ratio | 1.78* | 1.76* | 1.67* |

*Ratio is significant at a meaningful threshold of 5%
ICD, International Classification of diseases; SMR, standardized mortality ratio based on French national mortality rates; Q1, first quintile, the least deprived; Q5, fifth quintile, the most deprived; 95%CI, 95% Confident Interval

## Conclusion

The EPICES score, which measures the social and material dimensions of deprivation, is a reliable tool. In addition, this score, like the Townsend and Carstairs indices is related to all causes of death, most of the specific causes of death and to premature and avoidable deaths. Consequently, it can be used both at a national level to shape public health policies to reduce the mortality gap between the least and the most deprived and at a local level to promote the patient-centred medical home to improve primary health care. It would be interesting to study the metric characteristics of the EPICES score in other regions and countries and also in target populations such as expectant mothers.

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### Key points

- The EPICES score is a reliable tool to measure individual deprivation.
- The EPICES score is related to excess death rate and supports, therefore, that individual deprivation is a determinant factor of health.
- The EPICES score can be used to refine deprivation at an individual level in districts, as well as the Townsend and Carstairs indices, and so to support the development of new health policy at regional and individual level.

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