CHILDREN AGED 0-14 YEARS LIVING IN POVERTY	
GENERAL CONSIDERATIONS	
Issues	Perinatal diseases Respiratory diseases Diarrhoeal diseases Physical injuries
Type of indicator	Exposure (distal/driving force) Can also be used as a measure of action in relation to social policy.
Rationale	Poverty is a major risk factor for children's environmental health. It operates in three main ways. First, because of what has been termed environmental injustice, there is a marked tendency for the poorest in society to be more exposed to environmental hazards. This occurs both because the poor are more likely to live in inadequate housing, and in more hazardous areas, and because there is a tendency for polluting industries and other activities to congregate in poorer areas (e.g. because of lower land prices, less strict regulations and less effective opposition from the communities involved). Secondly, poverty tends to be associated with more harmful (or less self-protective) lifestyles and behaviours, for example in terms of diet, smoking, exercise and drug usage, both because of lack of awareness of the risks concerned and the lack of resources to avoid them. Thirdly, poverty makes it harder for those at risk to obtain treatment or help, often because of their remoteness from the necessary services, their lack of resources to access them and – in some cases – inherent biases and inadequacies within the services themselves. As a result, almost all environmental health effects show strong associations with poverty. Poverty thus represents an important, complex and inter-related set of social and environmental risks that cannot easily be separately specified. It also acts as an important confounder and modifier to relationships between many other risk factors and human health.
Issues in indicator design	Defining and measuring poverty is extremely difficult. Poverty is neither a unitary nor absolute condition. It is multi-facetted and contextual. No single, simple threshold or measure for poverty therefore exists that can be used as a basis for the indicator. Instead proxies of various types tend to be used. These are variously described in terms of poverty, deprivation, disadvantage or inequality. Some of these rely on single measures – such as disposable income, or family assets. Others use compound indices, often including a range of social, economic and, in some cases, health variables. The main example internationally is the UNDP Human Poverty Index (HPI), of which two forms have been devised, one for developed and one for developing countries. Various national indicators are also in use (e.g. the Carstairs Index which is widely used in the UK). Each of these indicators – and each of these approaches to devising indicators of poverty – has limitations. Indicators based on income alone, for example, take a very narrow view of poverty, and ignore the many other factors that influence social well-being – for example, customs that may limit the ability of some groups (e.g. women) to access, or benefit from, the available wealth. For the most part, compound indicators tend to be more powerful, but these are often highly contextual, and include variables that are not always widely relevant. Those (such as the UNDP HPI) that include variables relating directly to health (life expectancy, disability etc.) are not

	appropriate as *independent* measures of poverty, that can readily be used in combination with health indicators. Defining thresholds with any of these measures, below which people may be said to be living in poverty, is also difficult. On the other hand, merely taking an average measure across a population (e.g. average household income, or the average HPI) is misleading, because it fails to reflect the disparities in affluence and poverty that may exist within that population. Against this background, it is impossible to define a single indicator that will satisfy all circumstances and applications. The indicator proposed here attempts to define poverty in terms of both sustainable and disposable income, and its ability to meet basic needs. The concepts of income and need are defined generically, as a basis for indicator development, but in many cases would need to be further specified to take account of local circumstances (e.g. social structure, economic conditions, expectations). The age range of 0-14 years is taken because poverty affects children of all ages more or less equally.
SPECIFICATION	
Definition	Percentage (or number) of children aged 0-14 years living in households with a sustainable income inadequate to meet their basic needs.
Terms and concepts	***Sustainable and disposable income:*** the level of household income (in money or in kind) that is available to spend after primary commitments (e.g. taxation, tithes, travel and other costs involved in acquiring the income) have been paid, and that can realistically be expected to be maintained in the long term (i.e. over a period of one or more years). This income can be measured in different ways, depending on local circumstances, but should be converted to a common 'currency' (based on relative purchasing power) where international comparisons need to be made. ***Basic needs:*** the costs of essential life-support materials and services required to provide a healthy existence for a child within the local context. These should include all requirements for nutrition (to an acceptable, basic level), shelter (of a safe and adequate condition), education (to acquire essential literacy, numeracy and vocational skills) and health care (access to basic primary and secondary health care services). Costs of materials and services provided either via taxation or through direct deduction from income should not be included.
Data needs	Number of children aged 0-14 years by sustainable, disposable household income Costs of basic needs
Data sources	Data on household income can usually be obtained from national censuses or other routine surveys or registers (e.g. declarations to taxation offices). Where these sources are not available, sample data may be obtained from household surveys. In some cases, sample data are also collected by commercial companies (e.g. for marketing purposes). To estimate the disposable income it may be necessary to subtract from the reported income figures the levels of taxation and other routine deductions. To identify households with a sustainable income, it may be necessary to adjust the data according to employment rates (e.g. the percentage of people in long-term employment). Costs of basic needs should be calculated on the basis of an average 'basket' of goods, comprising essential food, shelter, education and health care. In some cases, national measures will be available (e.g. from national

	statistical offices or social service departments); otherwise, data to compute these costs may need to be obtained from household surveys.
Level of spatial aggregation	Administrative district (e.g. census tract)
Averaging period	Annual or longer
Computation	The indicator is computed as a simple percentage, as follows: *100* (Cpov / Ctot)* where : *Cpov* is the number of children aged 0-14 years living in households with a sustainable income inadequate to meet their basic needs; *Ctot* is the total number of children aged 0-14 years
Units of measurement	Percentage (or number)
Worked example	Assume that an area contains 15 000 households, with a total population of 62 000 children. Of these households, 6 400 (containing 31 400 children) are deemed to have a disposable and sustainable income below that needed to satisfy their basic needs. In this case, the indicator would be calculated as: *100 * 31 400 / 62 000 = 50.6%*
Interpretation	In general terms, an increase in the index value may be taken as an indication of increased poverty and an associated increase in the vulnerability of children to health problems, and reduced quality of life. Care is nevertheless necessary, especially in comparing countries or regions that differ markedly in terms of their culture, economy and way of life. Marked rural/urban differences may also occur, which may be masked where data are aggregated to large areas. The data needed to construct the indicator may also suffer from inaccuracies, inconsistencies and gaps, which might not be apparent in the reported statistics. Data on income, for example, are often subject to major uncertainties because of incorrect or incomplete reporting, and because of difficulties in assessing non-monetary or occasional income. Estimates of the cost of basic needs are also inherently uncertain, and likely to vary substantially from one country or population group to another. Minor differences in the indicator value are therefore unlikely to be meaningful and the indicator should only be seen to present a broad measure of poverty.
Variations and alternatives	Many alternatives to this indicator are possible. Examples include: ***Average household income per child:*** the mean household income (total or disposable) per child. ***Income disparity:*** the difference or range of incomes across the population. The UNCHS Household Income Distribution Indicator (UNCHS 1993), for example, is calculated as the ratio of the average income of the highest income quintile to the average income of the lowest income quintile. ***The poverty gap***: a measure of the difference between the poverty line and the level of consumption of all individuals in the population – e.g. the Poverty Gap Index (DAC 1999, UN 1996). ***Poverty or deprivation indices***: these typically assign an arithmetic score to individuals or areas based on a number of poverty or deprivation indicators (e.g. income, employment status, family situation, access to basic resources). Examples include the UNDP Human Poverty Index (UNDP

	1999), the Jarman score (Jarman 1983), the Townsend Index (Townsend *et al*. 1988), and the Carstairs score (Carstairs and Morris 1989).
Examples	WHO *Environmental health indicators: framework and methodologies* • **Poverty** UNDP *Human development report* • **Human poverty index for developing countries (HPI-1)** • **Human poverty index for developed countries (HPI-2)** *UN Indicators of sustainable development* • **Head count index of poverty** • **Poverty gap index** • **Squared poverty gap index** • **Gini index of income inequality** UNCHS and World Bank *Housing indicators programme* • **Household income distribution** • **Households below poverty line** • **DAC Indicators of poverty reduction** • **Incidence of extreme poverty** • **Poverty gap ratio** • **Inequality** Many indicators have also been developed at national level, often as a basis for allocating health resources e.g.: • **the Carstairs score** • **the Jarman score** • **the Townsend index**
Useful references	Carstairs, V. and Morris, R. 1989 Deprivation: explaining difference in mortality between Scotland and England and Wales. *British Medical Journal* 299, 886-889. DAC 1999: http://www.oecd.org/dac/indicators/htm/list.htm Gwatkin, D.R. and Guillot, M. 2000 *The burden of disease among the global poor. Current situation, future trends and implications for strategy.* Washington: World Bank. Jarman, B. 1983 Identification of underprivileged areas. *British Medical Journal* 286, 1705-1709. Townsend, P., Phillimore, P. and Beattie, A. 1988 *Health and deprivation: inequality and the north.* London: Croom Helm Ltd. UN *1996 Indicators of sustainable development. Framework and methodologies.* New York: United Nations. UNCHS (Habitat) and the World Bank 1993 *The Housing Indicators Programme*. Report and the Executive Director (Volume I). Nairobi: United Nations Centre for Human Settlements. UNCHS (Habitat) 1997 M*onitoring human settlements with urban indicators*.

	Nairobi: United Nations Centre for Human Settlements. UNDP 2000 *Human development report*. New York: United Nations. Wagstaff, A. 2002 Poverty and health sector inequalities. *Bulletin of the World Health Organization* 80, 97-105.

INTRAUTERINE GROWTH RETARDATION IN NEWBORN CHILDREN	
GENERAL CONSIDERATIONS	
Issues	Perinatal diseases Respiratory diseases
Type of indicator	Health outcome in the case of perinatal diseases; can also be used as a measure of action in relation to health policies and health service intervention). Exposure (distal/driving force) in the case of respiratory diseases.
Rationale	Birthweight is one of the most sensitive – and also one of the most important – measures of the well-being of children. Weight at birth is directly influenced by the general level of health status of the mother. In developing countries, especially, maternal nutrition is one of the most important determinants of birthweight. Three aspects are of particular importance: inadequate maternal nutritional status before conception, short stature of the mother (mostly due to undernutrition and repeated infections during childhood), and poor maternal nutrition during pregnancy. In developed countries the most important contributing factor to low birthweight is maternal smoking. Low birthweight is a particular risk factor. Children of low (or very low) birthweight have been variously identified as at increased risk from neurosensory, developmental, physical, and psychological problems. Specific problems include increased risk of cerebral palsy, asthma, upper and lower respiratory infections and ear infections. Low birthweight children are also likely to suffer from reduced rates of cognitive development and learning. Low birthweight also provides a powerful predictor of the future health of the child. Problems later in life include increased risks of coronary heart disease, diabetes and high blood pressure. Size at birth, however, reflects two factors: duration of gestation and rate of foetal growth. Thus birthweight should be considered with respect to gestational age. Ideally the preferred indicator should therefore be intrauterine growth retardation (IUGR). Small-for-gestational age or IUGR enables, for example, distinction between infants who are too small because they were born preterm and those who are small but at term. The best indicator for assessing foetal malnutrition is consequently birthweight for gestational age and gender.
Issues in indicator design	An infant suffering from IUGR is defined as being below the 10% percentile of the recommended gender-specific birthweight for gestational age reference curves (Williams 1982, WHO 1995). A cut-off of < 1500 g is recommended to identify infants with very low birthweight (VLBW). The application of this cut-off is useful in settings where many children are expected to be LBW and the health system is unable to cope with big numbers of infants referred for special care. In such circumstances VLBW infants are the most vulnerable and should obtain priority for care and special attention. For standardization purposes and in order to keep it simple one might consider selecting one indicator with one cut-off point. It is recommended to use IUGR and in the absence of gestational age information to use LBW (WHO, 1995). Compared to other health indicators, data are widely available: birthweight is one of the basic measures taken routinely at birth, in almost all health

	services. Data are less likely to be available, however, in more remote areas, where births are unsupervised. Thus, data may tend to be lacking or incomplete in the areas most affected by severe malnutrition.
SPECIFICATION	
Definition	Incidence of low or very low birthweight
Terms and concepts	***Intrauterine growth retardation:*** birthweight below the 10^{th} percentile of the recommended gender-specific birthweight for gestational age reference curves (Williams1982, WHO 1995). ***Number of live births*:** number of live births in the survey period
Data needs	Number of births by birthweight, gestational age and gender Total number of live births
Data sources, availability and quality	Birthweight is routinely collected only in developed countries where the great majority of births take place in health facility settings. According to statistics presented by UNICEF, two-thirds of all births world-wide are not weighed (UNICEF, 2001). Databases maintained by UNICEF and WHO rely primarily on facility-based and other routine reporting systems which are known to be biased when applied for national reporting purposes, particularly in developing countries. UNICEF has recently incorporated into their database household survey data (Demographic and Health Surveys and Multiple Indicator Cluster Surveys) using a subjective assessment by the mothers, qualifying their infants' size at birth as very large, larger than average, average, smaller than average, or very small. These estimates are of limited quality given that they are highly aggregated and the mother's subjective assessment of size tends to be biased towards the larger end of the scale (Blanc and Wardlow, 2002). Routine data on the number of live births are available from a number of sources, including vital registrations, sample registration systems, surveillance systems and censuses and demographic surveys (such as the demographic and health surveys of world fertility surveys). Information is also collated by the UN on a regular basis. Vital registration is incomplete in many parts of the world, however, and survey data are of varied quality, especially in remote rural areas. For this reason, rates based on civil registrations or hospital data may be biased towards the more affluent, urban sectors of the population.
Level of spatial aggregation	Administrative district
Averaging period	Annual
Computation	The indicator can be computed as: 100 * *Biugr / Blive* where: *Biugr* is the number of babies classified as affected by intrauterine growth retardation (i.e. below the 10 percentile of the recommended gender specific birthweight for gestational age reference curves (Williams,1982; WHO, 1995) during the survey period; *Blive* is the total number of live births during the survey period.
Units of measurement	Percentage
Worked example	Assume that there are 1 553 cases of IUGR in an area, from a total of 11 400 live births. In this case, the value of the indicator will be:

	100 * (1 553 / 11 400) = 13.6%
Interpretation	Impairments in foetal growth - as assessed by IUGR - can have adverse consequences in infancy and childhood in terms of mortality, morbidity, growth and performance (WHO, 1995). IUGR classification of a newborn has implications for diagnosis, prognosis, surveillance, and treatment. IUGR infants are more likely to have congenital anomalies, and surveillance of IUGR infants should include monitoring for oxygenation and respiratory status, neonatal sepsis, and neurological complications (WHO, 1995). Some care is needed in making comparisons between different countries, or over long time periods, however, because of changes in reporting mechanisms and efficiency. Differences may also exist in the definition of live births, while variations in the level of health service provision may affect survival of IUGR babies. Interpretation of trends or patterns in IUGR in relation to malnutrition also needs some degree of caution, since nutritional levels are not the only determinant of intrauterine growth. Other factors, such as smoking behaviour and exposure to air pollution may also be important.
Variations and alternatives	Following the recommendations made by the WHO Expert Committee (WHO, 1995), where gestational age is not available, birthweight < 2500 g (LBW) can be used as a proxy. It should be born in mind, however, that using LBW, considerably underestimates the magnitude of IUGR (de Onis et al, 1998). In more extreme situations, where many children are expected to have LBW and the health system is unable to cope with the large numbers of infants referred for special care, it may be more appropriate to use very low birthweight (VLBW) as a proxy. This is defined as children with a birthweight < 1500 g. VLBW infants are the most vulnerable and should obtain priority for care and special attention.
Examples	UNICEF *The state of the world's children* • **Percentage infants with low birthweight**
Useful references	ACC/SCN 2000 *The fourth report on the world nutrition situation: nutrition throughout the life cycle*. Geneva: Administrative Committee on Coordination, Subcommittee on Nutrition. Blanc, A.K. and Wardlaw, T. 2002 Survey data on low birthweight: an evaluation of recent international estimates and estimation procedures. *Annual Meeting of the Population Association of America, Atlanta, May 9-11, 2002*. de Onis, M., Frongillo, E.A. Jr. and Blössner, M. 2000 Is malnutrition declining? An analysis of changes in levels of child malnutrition since 1980. *Bulletin of the World Health Organization* 78, 1222-33. Mosley, W.H. and Gray, R. 1993 Childhood precursors of adult mortality in developing countries: implications for health programs. In: Gribble, J. and Preston, S.H. *The Epidemiological Transition: Policy and Planning Implications for developing countries.* Washington: National Academy Press, Pp. 69-100. UNICEF 2000 *The state of the world's children, 2000.* Progress since the World Summit for Children: A statistical review. New York: United Nations Children's Fund, 2001. (Available at http://www.unicef.org/sowc00/)

	UNICEF website: www.childinfo.org/eddb/lbw/index.htm WHO 1995 *Expert Committee Report: Physical status: the use and interpretation of anthropometry. Technical Report Series 854.* Geneva: World Health Organization. WHO 1996 *Catalogue of Health Indicators: A selection of important health indicators recommended by WHO Programmes.* WHO/HST/SCI/96.8. Geneva: World Health Organization. WHO 1997 *The WHO Global Database on Child Growth and Malnutrition*. WHO/NUT/97.4. Geneva: World Health Organization. Williams, R.L., Creasy, R.K., Cunningham, G.C., Hawes, W.E., Norris, F.D. and Tashiro, M. 1982 Fetal growth and perinatal viability in California. *Obstetrics and Gynecology* 59, 624-32.

CHILDREN AGED 0-14 YEARS LIVING IN UNSAFE, UNHEALTHY OR HAZARDOUS HOUSING	
GENERAL CONSIDERATIONS	
Issues	Respiratory diseases Physical injuries
Type of indicator	Exposure (proximal) Can also be used as a measure of action in relation to housing quality.
Rationale	The adequacy of housing is an important determinant of the health status of children. *Inter alia*, housing quality affects levels of exposure to indoor pollutants, food and water hygiene, levels of sanitation, exposures to physical hazards and injury, and general quality of life. Housing may be unsafe, therefore, for a variety of reasons, including: dangerous construction, inadequate ventilation, inadequate heating, dangerous or inadequately maintained services, inadequate size for the number of residents (i.e. overcrowding), location in a hazardous area (e.g. areas prone to flooding or earthquakes, or on contaminated land) or the presence of dangerous contaminants (e.g. lead or radon) in the building materials. Living in inadequate housing is therefore likely to result in increased risks of a variety of health effects, including respiratory illness and physical injury.
Issues in indicator design	Although potentially valuable, this indicator is difficult to define and measure in a clear and systematic manner. In many cases, the most appropriate measure may be the percentage (or number) of children living in unsafe, unhealthy or hazardous housing. Defining the terms ‘unsafe’, ‘unhealthy’ and ‘hazardous’, however, poses severe difficulties for these are all to a large extent both environmentally and culturally dependent, and thus are liable to vary from one area (or one time) to another. Possible definitions of unsafe, unhealthy or hazardous housing include housing which is: • **physically unsound and likely to be dangerous to its occupants, because of its poor construction, or inadequately maintained services (e.g. electricity); or** • **is located in a physically hazardous area (e.g. an area of flood or earthquake risk) or is sited on contaminated land (e.g. by chemical wastes, radioactivity); or** • **provides serious risks of exposures to indoor pollution (e.g. air pollutants) or pathogens (e.g. moulds, ticks, fleas); or** • **provides inadequate shelter (e.g. due to poor insulation, inadequate roofing) and basic amenities (e.g. cooking facilities, heating).** Problems may also exist in devising a single indicator that combines all these different conditions in a single measure, since in terms of health they may not be equivalent. As an alternative, therefore, separate indicators can be developed, relating to specific aspects of housing condition and quality. Thus, indicators might be compiled of overcrowding, access to basic amenities, indoor air pollution, flood risk, avalanche risk, earthquake risk etc. The disadvantages of this approach are the large number of indicators that might need to be compiled, and the difficulties of comparing between them or of using them to provide a general overview of housing conditions. An age range of 0-14 years is applied in the case of this indicator because the various risks from hazardous housing conditions affect children of all

	ages.
SPECIFICATION	
Definition	Percentage (or number) of children aged 0-14 years living in unsafe, unhealthy or hazardous housing.
Terms and concepts	This indicator requires the ability to identify, and measure the extent of, unsafe, unhealthy or hazardous housing. This may be generally defined as housing which is: • **physically unsound and likely to be dangerous to its occupants, because of its poor construction, or inadequately maintained services (e.g. electricity); or** • **is located in a physically hazardous area (e.g. an area of flood or earthquake risk) or is sited on contaminated land (e.g. by chemical wastes, radioactivity); or** • **provides serious risks of exposures to indoor pollution (e.g. air pollutants) or pathogens (e.g. moulds, ticks, fleas); or** • **provides inadequate shelter (e.g. due to poor insulation, inadequate roofing) and basic amenities (e.g. cooking facilities, heating).** These definitions may need to be adjusted locally to meet specific circumstances. In addition, a definition is required of the total number of children: i.e. the total resident population of children aged 0-14 years, at the time of census or survey.
Data needs	Number of children aged 0-14 years living in unsafe, unhealthy or hazardous housing. Total resident population of children aged 0-14 years.
Data sources, availability and quality	Data on the quality of the housing stock, and the number of children living in unsafe, unhealthy or hazardous housing is rarely available from routine sources. In some countries, an approximation to this may be available from census statistics (e.g. housing lacking basic amenities). Generally, however, data will need to be obtained by special surveys. In all cases, these data are liable to considerable margins of error and inconsistency due to difficulties of definition, inconsistent reporting and difficulties of ensuring representative sampling. Data on the total resident population of children should be available from national censuses and should be reliable.
Level of spatial aggregation	Community, administrative district or region
Averaging period	Annual or longer term
Computation	The indicator can be computed as: *100 * Cunsafe / Ctot* where: *Cunsafe* is the number of children aged 0-14 years living in unsafe, unhealthy or hazardous housing; *Ctot* is the total population of children aged 0-14 years
Units of measurement	Percentage or number
Worked example	Assume that a survey of housing conditions shows that 1 440 children, from a total sample of 11 070 children, are found to be living in homes classified

	as unsafe, unhealthy or hazardous. In this case the value of the indicator is: 100 * 1 440 / 11 070) = 13.0%
Interpretation	This is an important indicator, which has wide-ranging significance for policy. In providing a measure of the adequacy of the housing stock, it also acts as an indicator of health risks associated with poor sanitation, exposures to indoor air pollution, and access to safe water. It can, therefore, help to interpret a range of other issues and indicators. Like all general-purpose indicators, however, it needs to be interpreted carefully. The characteristics which render housing unsafe, unhealthy or hazardous may clearly vary; without information on these specific characteristics it can be misleading to infer either the existence of particular health risks or effects or the need for specific actions. Definitional issues are also likely to pose major difficulties for comparisons between different areas, or between different surveys, unless standard protocols have been used. A clear understanding of the data is therefore essential before interpretations are made.
Variations and alternatives	This indicator can be based upon a wide range of locally defined classifications of housing quality – for example, temporary or non-permanent housing, housing without adequate amenities, housing built on unsafe or unstable land, or houses at risk of flooding. It can also be applied to different age ranges (e.g. children 0-5 years in age), as appropriate.
Examples	WHO *Environmental health indicators: framework and methodologies* • **Population living in unsafe housing** UNCHS (Habitat) *Urban Indicators Programme* • **Permanent structures (percentage of housing units located in structures expected to maintain their stability for 20 years or longer under local conditions with normal maintenance);** • **Housing in compliance (percentage of the total housing stock in compliance with current regulations);** • **Housing destroyed (percentage of the housing stock destroyed by natural or man-made disasters over the past ten years).**
Useful references	UNCHS Urban Indicators Programme: http://www.urbanobservatory.org/indicators/database/ WHO 1999 *Environmental health indicators: framework and methodologies.* Geneva: World Health Organization. (Available at http://www.who.int/docstore/peh/archives/EHIndicators.pdf)

OVERCROWDING	
GENERAL CONSIDERATIONS	
Issues	Respiratory diseases
Type of indicator	Exposure (proximal)
Rationale	The increased likelihood of disease transmission that occurs in overcrowded environments, means that occupational densities are an important risk factor for a wide range of respiratory diseases, including pneumonia, tuberculosis and many allergies.
Issues in indicator design	Overcrowding can probably best be measured in terms of the average living area per person in the place of residence. Alternatively, if a suitable norm or target for 'overcrowding' can be defined (e.g. the minimum acceptable living area per person), it can be computed as the percentage or number of children living in overcrowded homes. In either case, however, information is needed on both the number of residents in each home and the available living area: the latter, especially, is not always available and can be difficult to define, especially where people spend large amounts of time outdoors, where homes comprise multiple, separate units or in nomadic/semi-nomadic communities. Alternatively, the indicator may be expressed simply as the average number of people per dwelling unit. Clearly this is less satisfactory since it takes no account of the size of the dwelling unit. Problems may also exist in this case in defining a dwelling. UNCHS (1995) define this as 'a space in a housing unit, or other living quarters enclosed by walls reaching from the floor to the ceiling or roof covering, at least to a height of two metres, of a size large enough to hold a bed for an adult'
SPECIFICATION	
Definition	Average floor area per person
Terms and concepts	***Floor area***: area (m^2) of usable floorspace in occupied dwellings. ***Dwelling***: a housing unit or other living quarters, enclosed by walls at least 2 metres high and completely covered by a ceiling or roof, forming an area large enough to hold a bed for an adult. ***Total resident population***: total number of people resident in the area (whether or not they live in a dwelling as defined above).
Data needs	Total floor area in occupied dwellings Total resident population
Data sources, availability and quality	Data on the floorspace in dwellings may be obtainable from national censuses, in which case data are likely to be reliable. Where census statistics are not available, information may be collected through household surveys. Estimates may also be made from aerial photographs, satellite imagery or maps, if necessary. Data on total resident population should also usually be available from routine censuses and should thus be of a reasonable standard.
Level of spatial aggregation	Community or administrative district
Averaging period	Annual or longer term
Computation	The indicator can be computed as: *Ptot / Favail*

	where: *Ptot* is the total resident population; *F* is the available floorspace in dwellings.
Units of measurement	Square metres per person
Worked example	Assume that an area has a population of 13 750 people and a total floor space in dwellings of 92 125 m^2. In this case, the value of the indicator is: 92 125 / 13 750 = 6.7 m^2/person
Interpretation	This indicator can be interpreted as a measure of the degree of over-crowding in households: the higher the indicator value, the more over-crowded housing conditions are. As such, it indicates risks of respiratory (and other) infections in children. For several reasons, however, the indicator needs to be interpreted with care. The first is that, like any indicator based on a measure of central tendency, it takes no account of the degree of spread within the population. Thus, a small number of very large houses may bias the indicator value upwards. Problems may also occur in obtaining consistent measures of floorspace. Variations in the quality of this floorspace are also not shown by the indicator.
Variations and alternatives	This indicator can be defined and computed in many different ways. One alternative, which may be more appropriate at the local scale, is to compute the median available floorspace per person. This can be calculated by measuring the floorspace per person in each household separately, ranking these, and then taking the midpoint (50^{th} percentile) value. This has the advantage of being less affected by extreme values. Other alternatives include number of persons/bedroom, bedroom area/person, number of persons/room, number of persons/housing unit. Each of these indicators may also be computed in terms of the number of children (rather than total population), though to do so can be misleading since variations may reflect variations in family structure, rather than degree of overcrowding. Another alternative is to calculate the number or percentage of children living in overcrowded households. This requires an explicit definition of 'overcrowding'; one such definition (Abu Helwa and Birch 1993) is 2.5 persons per room. Thus all children living in households with more than 2.5 persons per room would be classed as overcrowded.
Examples	*UNCHS Monitoring human settlements with urban indicators* • **Average household size**
Useful references	Abu Helwa, M. and Birch, B. 1993 The demography and housing conditions of Palestinian refugees in and around the camps in Amman, Jordan, *Journal of Refugee Studies*, 6 (4), 403-13. Clauson-Kaas, J. *et al.* 1996 Urban health: human settlement indicators of crowding," *Third World Planning Review* 18 (3), 349-63. UNCHS (Habitat) 1995 *Human settlement interventions addressing crowding and health issues*. Nairobi: United Nations Centre for Human Settlements. UNCHS Urban Indicators Programme: http://www.urbanobservatory.org/indicators/database/ Marshy, M. 1999 *Social and Psychological Effects of Overcrowding in Palestinian Refugee Camps in the West Bank and Gaza. Literature Review and Preliminary Assessment of the Problem.* International Development Research Centre, Ottawa, Canada. (Available at http://www.arts.mcgill.ca/MEPP/PRRN/marshy.html#2)

CHILDREN AGED 0-14 YEARS LIVING IN PROXIMITY TO HEAVILY TRAFFICKED ROADS	
GENERAL CONSIDERATIONS	
Issues	Respiratory diseases Physical injuries
Type of indicator	Exposure (proximal)
Rationale	Road traffic represents an important source of risk for children, both as a result of physical injuries and respiratory illness due to exposures to vehicle emissions. Risks are growing in many areas not only because of increased traffic volumes, but in some cases also because of population growth in areas close to busy roads. In all cases, children are especially vulnerable. They tend to receive higher doses from vehicle emissions, for example, because they spend much of their time at home and, when in the street, have a breathing height that is often close to the emission source. They are also more prone to physical injury because they are likely to be less aware of the dangers to which they are exposed, are less easily seen and avoided by vehicle drivers, are bodily more fragile, and in many cases spend more time as pedestrians (e.g. playing on the streets) than do adults.
Issues in indicator design	This is a relatively non-specific exposure indicator in that it takes no direct account either of the vehicle emissions that are most important for children's respiratory health, or the road and vehicle characteristics (e.g. speed) that most directly pose risks of injury. On the other hand, it is useful as a general indicator because it provides a way of representing the collective risks from road traffic. Several approaches can be taken to designing this indicator. For example, it can be defined in terms of the levels of traffic on residential roads, the numbers of children living close to busy roads, or the population-weighted distance to the nearest road. Each poses some problems, for they all require the ability to identify where children live in relation to roads, and in some cases the level of vehicle usage on these roads. This implies the availability of geographically disaggregated data (i.e. at a scale below generalized administrative regions). GIS techniques may be useful in this context to analyse spatial relationships between road traffic networks and residential areas. An age range of 0-14 years is used in this indicator because risks from road traffic persist throughout the child's life – and in many cases increase in school-age children.
SPECIFICATION	
Definition	Percentage (or number) of children aged 0-14 years living in proximity to heavily trafficked roads.
Terms and concepts	***Living in proximity to heavily trafficked roads***: living in a house that directly adjoins or lies within ca. 50 metres of a heavily trafficked road. ***Heavily trafficked roads***: a road carrying a more-or-less constant flow of traffic – at a rate of at least one vehicle per minute (60 vehicles per hour). ***Children aged 0-14 years:*** resident children aged 0-14 years at the survey date.
Data needs	Road network

	Traffic volumes Place of residence Numbers of children aged 0-14 years
Data sources, availability and quality	Data on the road network can usually be obtained from the relevant highways authorities or local authorities; road network data can also be derived from road or topographic maps and aerial photographs. Especially when in digital form, these data are likely to be reliable, though generalized data may omit smaller, often residential streets. Data on traffic volumes can usually be provided by the highways or local authorities. Counts are commonly based on short (e.g. 1-2 day or week) surveys, and may not be wholly representative of traffic flows, but should be sufficient to permit classification of roads according to their traffic volume. Small roads are often not covered by these data. Where count data are not available, estimates may be made using traffic models (e.g. trip generation or vehicle assignment models). More crudely, estimates can also be made by extrapolation of data from elsewhere: for example, by classifying roads on the basis of counts or modelled data for similar types of road. High resolution data on residential locations can often be obtained from local authorities (e.g. planning maps), from postal sources (e.g. postcode data) or from household surveys. Where none of these are available, broader scale data (e.g. census information) may be disaggregated to a more local level using GIS techniques. Land cover data – e.g. from satellites or aerial photography – can also be used to identify residential areas, and to disaggregate population data to a finer spatial scale.
Level of spatial aggregation	Community or municipality
Averaging period	Annual or longer term
Computation	The indicator is best computed using a GIS to intersect data on the residential distribution of children aged 0-14 years with data on road networks and traffic volumes. Roads classified as having a traffic volume greater than 60 vehicles per hour are then buffered to a distance of 50 metres, and overlaid with the population map. The percentage of children living within the 50 metre buffer zone along these roads is then computed, either using point-in-polygon techniques (where the population is available on a point basis) or by proportional area (where the population is available for areal units). The indicator is then given by: $100 * Cnear / Ctot$ where: *Cnear* is the number of children aged 0-14 years living within the 50 metre buffer zone; *Ctot* is the total number of children aged 0-14 years in the area as a whole.
Units of measurement	Percentage or number

Worked example	Assume that in one city 47 500 children, out of a total of 195 000 children are found to be living within 50 metres of heavily trafficked streets. In this case, the value of the indicator is: $100 * (47\,500 / 195\,000) = 24.4\%$
Interpretation	This indicator provides a useful general measure of the level of exposure of children to road traffic, since it measures the percentage of children living close to busy roads. An increase in this indicator thus implies that more children are at risk of traffic accidents or respiratory illness due to exposure from vehicle emissions, while a decrease in the indicator implies a reduction in risk. For various reasons, however, these interpretations need to be made with care. The first problem is the quality of the available data: often the indicator will require some degree of approximation, so small changes in the indicator value may not be significant. Secondly, it needs to be appreciated that traffic volumes – and residential proximity to heavily trafficked roads – are not direct measures of accident risk or exposure; many other factors, such as road layout, building configuration, driver behaviour, traffic speed, behaviour of children, are also important.
Variations and alternatives	This indicator can be constructed using different definitions both of 'heavily trafficked roads' and of 'proximity' (both the criteria used here are essentially arbitrary). For example, higher traffic and distances of less than 50 metres might be more appropriate where the aim is to assess variations in risk within large, densely populated cities. The indicator may also be varied to focus on a narrower age range (e.g. 0-4 years). As an alternative, the indicator may also be expressed as the traffic volume on residential roads. In this case, a baseline definition is required of residential areas (e.g. based on land use data or population statistics). Average traffic volumes on roads passing through these residential areas may then be computed. Ideally they should then be expressed as vehicle kilometres per 1000 children (or per 1 km^2) in order to give a measure of the *intensity* of road traffic in these areas. In this form the indicator is more sensitive to changes in traffic volume (especially over time); however, it does not necessarily reflect the degree of proximity of roads to the place of residence. A further alternative is to estimate the population weighted average distance to the nearest busy road. This can readily be done using GIS techniques – for example by averaging the distance of each place of residence to the nearest busy road. Again, this requires a definition of a busy road.
Examples	None known (though the indicator is widely used as a measure of exposure in epidemiological studies).
Useful references	Banos, A. and Huguenin-Richard, F. 1999 Spatial distribution of road accidents in the vicinity of point sources: application to child pedestrian accidents. In: *Geography and Medicine. Proceedings of the Second International Workshop on Geomedical Systems.* (A. Flahaut, L. Toubiana, and A.J. Valleron, eds.), pp. 54-64. Brunekreef, B., Janssen, N.A., de Hartog, J., Harssema, H., Knape, M. and van Vliet, P. 1997 Air pollution from truck traffic and lung function in children living near motorways. *Epidemiology* 8, 298-303. Oosterlee, A., Drijver, M., Lebret, E. and Brunekreef, B. 1996 Chronic respiratory symptoms in children and adults living along streets with high traffic density. *Occupational and Environmental Medicine* 53, 241-7.

	Van Vliet, Knape, M., de Hartog, J., Janssen, N., Harssema, H. and Brunekreef, B. 1997 Motor vehicle exhaust and chronic respiratory symptoms in children living near freeways. *Environmental Research* 74, 122-32. Venn, A.J., Lewis, S.A., Cooper, M., Hubbard, R. and Britton, J. 2001 Living near a main road and the risk of wheezing illness in children. *American Journal of Respiratory Critical Care Medicine* 164, 2177-80.

MEAN ANNUAL EXPOSURE OF CHILDREN AGED 0-4 YEARS TO ATMOSPHERIC PARTICULATE POLLUTION	
GENERAL CONSIDERATIONS	
Issues	Respiratory disease
Type of indicator	Exposure (proximal) Can also be used as a measure of action for air quality policies.
Rationale	Exposure to air pollution in the ambient environment poses severe health risks for children. Short periods of high level exposure are known to be implicated in acute respiratory responses (e.g. reduced lung function, wheezing, asthma attacks). These risks are exacerbated, in many cases, by the relatively long periods of time that children often spend outdoors and their small stature – which means that they are inhaling more polluted air than that inhaled by adults. Sensitization to air pollution at an early age may also increase long-term susceptibility to air pollution and contribute to risks of chronic health effects in later life. Many different sources may contribute to ambient emissions of air pollution, including road traffic, industry, agriculture, waste activities and natural processes. Many different pollutants may also pose risks to children's health, including particulates, nitrogen oxides, carbon monoxide, sulphur oxides, ozone, volatile organic compounds (e.g. benzene, a-pryobenzene), metals (e.g. lead, cadmium, mercury) and organic agents (e.g. pollen, infectious organisms). These may act individually or in combination to affect health: for example interactions appear to occur between exposures to air pollution and pollen. Developing general indicators which capture these complex risk factors within a single measure is, therefore, difficult, and indicators may need to be adapted to reflect specific circumstances (e.g. the range of pollutants or emission sources that occur locally). Fine particles, however, represent one of the most important pollutants in terms of respiratory illness, and also act as relatively reliable markers for a number of other pollutants. Exposures to particles, therefore, provides a useful indicator of risks from air pollution.
Issues in indicator design	Various ways can be devised for defining this indicator, but the best is probably in terms of the average exposure of young children to atmospheric particulates. Children in the age range of 0-4 years are especially sensitive to air pollution, so should provide the target group. Several difficulties nevertheless occur in developing the indicator in this way. One is the lack of any universally adopted means of either defining or measuring atmospheric particulates. Common definitions include total suspended particulates (TSP), PM_{10} (i.e. particles with a median equivalent diameter of 10 μm), $PM_{2.5}$ and black smoke. Each of these represents a different size (and thus compositional) fraction of the particles found in the atmosphere, and each may have somewhat different health implications. Measurement methods also vary: typically particles are measured gravimetrically (as a measure of mass), by optical techniques (often as a particle count) or by reflectance (e.g. black smoke). Data provided by these different methods are not directly comparable, and attention therefore needs to be given to the data characteristics when constructing the indicator. Although much of the epidemiological research on respiratory illness has focused on the PM_{10} fraction, more recent findings have tended to emphasize the importance of the finer fraction (e.g. $PM_{2.5}$ or PM_1). These finer fractions, however, are less widely monitored than PM_{10}. There is also some new evidence to suggest that black smoke (or elemental carbon) is a

	good measure of the inhalable fraction of greatest concern. Concentrations of black smoke and PM_{10} also tend to be quite closely correlated, so they can, to some extent, be substituted for each other as a basis for indicator development. Local calibration of this association may be necessary, however, to provide an appropriate adjustment factor. Difficulties also arise in estimating exposures. Monitoring of particulate concentrations is often sparse: even in large cities there may be only one or a few monitors to represent several million people; in rural areas, monitoring may be almost non-existent. Monitoring stations are also often highly biased in their distribution towards certain types of site (often depending on their specific purpose). As a consequence, simply averaging data from several monitoring sites, or using the nearest site to represent exposures, can be highly misleading. Instead, sites need to be selected that are considered representative of exposures, or more sophisticated modelling methods should be used to estimate population-weighted exposures. Differences in these assessment techniques can again be a source of inconsistency in the indicator. A further consideration is the averaging period to use for exposure assessment. Air pollution has both acute and chronic effects. Acute effects are often exacerbated by short periods of raised pollution, which are best represented by daily peak exposures. Chronic effects may be due to long-term exposures, perhaps over many years. These are best represented by average annual exposures. Though short- and long-term exposures tend to be loosely related (because short-term peaks tend to occur in areas which are also more polluted in the long-term), they do not always give comparable classifications of exposure within a population. Average annual exposures are, however, probably easier to assess and more reliable, because they are less sensitive to short term meteorological conditions or behavioural patterns, that may affect exposures from day to day.
SPECIFICATION	
Definition	Mean annual exposure of children aged 0-4 years to atmospheric particulate pollution.
Terms and concepts	***Mean annual exposure:*** the mean, population-weighted exposure, averaged over a year. ***Atmospheric particulate pollution:*** ambient concentrations of PM_{10} (or their equivalent).
Data needs	Mean annual concentrations of PM_{10} at a standard height (usually ca. 2 metres); or mean annual concentrations of black smoke (or TSP) and a locally validated calibration factor to convert this to PM_{10} equivalent Numbers of resident children aged 0-4 years.
Data sources, availability and quality	Data on particulate (or black smoke) concentration can usually be obtained from monitoring networks, run either by national or municipal agencies. As noted above, variations in the definition of the target pollutant and the monitoring methods may exist, and the sites may not be representative of population exposures. Representative sites should thus be selected where necessary. Monitoring is also not always carried out continuously, so data may need to be adjusted to provide estimates of mean annual concentrations. Conversion factors for translating black smoke or TSP concentrations into PM_{10} equivalent are often available from previous studies, or can be obtained by analysing data from co-located monitors. Data on numbers of resident children are usually available from national censuses and should be relatively reliable.
Level of spatial aggregation	Community, administrative area or municipality

Averaging period	Annual (or seasonal, where strong seasonal differences occur)
Computation	Computation of the indicator requires monitoring data to be linked to population distribution, to give a population-weighted measure of mean annual exposure. With the aid of GIS techniques, this can best be done by identifying sites that are representative of residential areas, and then either: 1) averaging these to provide a measure of exposure across the population as a whole; or 2) interpolating between these sites using geostatistical or other techniques, then intersecting the resulting map with the population distribution to derive a population-weighted exposure measure. The latter is likely to be more reliable, so long as a sufficient number of monitoring sites are available. By method 1, therefore, the indicator is computed as: $\Sigma\,(Pres\,/\,Nres)$ where: *Pres* is the annual concentration of particulates measured at each site considered to represent residential locations in the area; *Nres* is the number of residential monitoring sites in the area. By method 2, the indicator is computed as: $\Sigma\,(Psub * Csub)\,/\,Ctot$ where: *Psub* is the annual concentration of particulates in each subarea for which as estimate can be made; *Csub* is the population of children aged 0-4 years in each subarea for which an estimate can be made; *Ctot* is the number of children aged 0-4 years resident in all the subareas.
Units of measurement	Concentration ($\mu g/m^3$ or ppb)
Worked example	By method 1, assume that there are five monitoring stations within a city, of which three are considered to be representative of residential areas. Assume, also, that the annual concentration measured in each of these is 60, 75 and 110 $\mu g/m^3$. In this case, the value of the indicator is calculated as: (60 + 75 + 110) / 3 = 81.7 $\mu m/m^3$ By method 2, assume that data from these three stations have been interpolated to give estimates for seven subareas in the city, with concentrations (and resident populations of children) as follows: subarea A = 30 $\mu m/m^3$ (910 children) subarea B = 45 $\mu m/m^3$ (1200 children) subarea C = 50 $\mu m/m^3$ (600 children) subarea D = 80 $\mu m/m^3$ (720 children) subarea E = 97 $\mu m/m^3$ (320 children) subarea F = 120 $\mu m/m^3$ (1 400 children) subarea G = 135 $\mu m/m^3$ (260 children) In this case the value of the indicator would be calculated as: [(30*910)+(45*1200)+(50*600)+(80*720)+(97*320)+(120*1400)+(135*260)] / 5 400 = 74.6 $\mu m/m^3$
Interpretation	This indicator can be interpreted as a measure of children's exposures to ambient atmospheric particular pollution. The main sources of this pollution are likely to be combustion sources such as road traffic, industry, domestic

	heating and forest fires. An increase in the indicator can be interpreted as evidence of increased exposure to pollution from these sources, and a consequent increase in risks to respiratory health; a reduction in the indicator implies a decline in exposures and associated health risks. Several factors nevertheless need to be considered in using the indicator. The first is that particulate pollution is only one component of air pollution, and not always the most important in terms of respiratory illness. Other pollutants – e.g. ozone, NO_2 and other particle size fractions– may also be important in some cases. Secondly, the uncertainties inherent in the data need to be recognized – in particular, where monitoring stations are sparse so that data have had to be extrapolated over large areas in order to derive exposure measures. Thirdly, it needs to be remembered that populations may differ substantially in terms of their susceptibility to these exposures (e.g. due to differences in general health or past exposure history), so areas or periods of higher pollution do not always imply increased health risk. Finally, it needs to be noted that ambient air pollution is often not the main source of exposure for children: indoor exposures are often far more significant.
Variations and alternatives	Many different variations on this indicator are possible. Obvious alternatives include the use of different measures of particulates (e.g. TSP, $PM_{2.5}$) or other pollutant species (e.g. NO_2, SO_2). The indicator can also be measured for shorter averaging times (e.g. daily peak exposure) where appropriate. Where data on population are not available – or extrapolation to give population-weighted measures is not considered appropriate – mean ambient pollutant concentrations of these pollutants can be used as a proxy. It is also possible in principle to compute a measure of exposure to multiple pollutants. If the relative dose-response relationships (or toxicities) of these different pollutants are known, their concentrations can be weighted and averaged to give a combined pollutant index. This can then be adjusted to reflect the numbers of children exposed using the methods outlined above. Alternatively, the different pollutants can be standardized by computing their percentage exceedance of air quality guideline values, before summing to give a measure of exposure. Where guidelines have not been established, mean annual concentrations from a nearby rural site may be used as a reference value.
Examples	UN *Indicators of sustainable development* • **Ambient concentrations of pollutants in urban areas** WHO *Environmental health indicators: framework and methodologies* • **Ambient concentrations of air pollutants in urban areas** WHO *Environmental health indicators for the European region* • **Annual average concentration of NO_2, PM_{10} and SO_2, and 8 hr weighted O_3, in relation to reference values**
Useful references	UN *1996 Indicators of sustainable development. Framework and methodologies*. New York: United Nations. WHO 1999 *Environmental health indicators: framework and methodologies.* Geneva: World Health Organization. (Available at http://www.who.int/docstore/peh/archives/EHIndicators.pdf) WHO 2000 *Air Quality Guidelines for Europe. Second edition.* WHO Regional Publications, European Series No. 91. Geneva: World Health Organization. WHO 2000 *Guidelines for air quality.* Geneva: World Health Organization. WHO 2002 *Environmental health indicators: development of a methodology*

	for the WHO European region. Bonn: World Health Organization. WHO Healthy Cities Air Management Information System (AMIS).

CHILDREN AGED 0-4 YEARS LIVING IN HOUSEHOLDS USING BIOMASS FUELS OR COAL AS THE MAIN SOURCE OF HEATING AND COOKING	
GENERAL CONSIDERATIONS	
Issues	Respiratory diseases
Type of indicator	Exposure (proximal)
Rationale	Children spend a large proportion of their time indoors, either at home or at school. Levels of air pollution in the indoor environment are therefore important determinants of exposures to air pollutants, and thus of children's health. Short periods of high level exposure are known to be implicated in acute respiratory responses (e.g. reduced lung function, wheezing, asthma attacks). Sensitization to air pollution at an early age may also increase long-term susceptibility to air pollution and contribute to risks of chronic health effects in later life. Much of the pollution found indoors derives from outdoor sources; indoor concentrations thus depend in part on outdoor concentrations. Rates of ingress into, and egress from, buildings depend mainly on ventilation conditions, meteorology (e.g. temperature, wind speed, atmospheric pressure) and behavioural patterns of the occupants. Occupants themselves (both humans and pets) may introduce large quantities of pollutants into the home, for example on their clothes or feet, which are then recycled in the indoor air. In addition, a wide range of indoor sources and activities add to the pollutant concentrations in the home, including smoking, cooking, heating, chemicals usage and releases from furnishings. Indeed, these internal releases are often responsible for the major peaks in exposure experienced by children. Many different pollutants thus occur in the indoor environment, and many of these may pose risks to children's health. These include particulates, nitrogen oxides, carbon monoxide, sulphur oxides, ozone, volatile organic compounds (e.g. benzene, a-pryobenzene), metals (e.g. asbestos, lead, cadmium, mercury), radon, and organic agents and allergens (e.g. dust mite, fungi, moulds). These may act individually or in combination to affect health: for example risks from radon exposure seem to be exacerbated by environmental tobacco smoke. Combustion of biomass fuels in unvented (or poorly vented) stoves and fires for cooking and heating, together with smoking, often represent the most important indoor sources. Pollutants emitted from these sources include particles, carbon monoxide, sulphur dioxide, nitrogen dioxide and volatile organic compounds (of which a number are known or suspected carcinogens). In poorly vented environments, particles and carbon monoxide are often found at especially high levels and pose particular health threats. Potential health effects include acute respiratory infection, chronic pulmonary disease, cancer, tuberculosis, reduced birthweight and eye damage.
Issues in indicator design	As with outdoor air pollution, the ideal indicator would be based on monitoring of air pollution in the indoor environment. Such data are, however, generally lacking, except where specific monitoring campaigns have been conducted (e.g. using personal monitoring). Even then, problems can occur, because of the wide range of pollutants potentially of interest. On the one hand, if separate indicators are developed for each pollutant, it becomes difficult to interpret these in any holistic way; on the other hand, difficulties occur in trying to combine data on individual pollutants into a

	composite indicator of indoor air pollution (especially in the absence of widely accepted indoor air quality targets or standards). In most cases, therefore, indicators of indoor air pollution are computed in terms of indoor emission sources. The sources considered may vary according to local circumstances, but major sources of concern typically include smoking (environmental tobacco smoke), heating and cooking (e.g. fuel types and degree of emission control of heating and cooking facilities), building materials (e.g. asbestos, radon), geological sources (radon) and organic sources (e.g. dust mite, moulds). Describing these various sources in a consistent way, and combining them into a general index of indoor pollution sources, is nevertheless difficult. Possibly the best approach is to assess the percentage of premises (or their occupants) having specific types of indoor emission sources. Examples might be the proportion of homes in which adults smoke, or the proportion of homes with unvented gas or fossil fuel cookers and heaters. Alternatively, the indicator could be defined as the percentage of households connected to electricity and gas supplies. In each case, relevant data are often available from specially designed household surveys, from utility companies or perhaps from routine censuses and surveys. Here the focus is on use of biomass fuels indoors, since these are commonly a major source of children's exposure, and a major risk factor for respiratory health. An age range of 0-4 years is used because risks tend to be greatest for pre-school age children, who spend more of their time at home.
SPECIFICATION	
Definition	Percentage (or number) of children aged 0-4 years living in households using coal, wood or dung as the main source of heating and cooking fuel.
Terms and concepts	***Household***: a single dwelling unit (e.g. a house or apartment) intended for permanent residence. ***Use of coal, wood or dung as the main source of cooking or heating fuel***: the reliance on coal (or lignite), wood or dung as the primary cooking or heating fuel in the home.
Data needs	Number of children aged 0-4 years by type of fuel usage in the home.
Data sources, availability and quality	Data on number of households using coal, wood or dung as the main source of cooking and heating fuel may be available from census statistics or household surveys, and in these cases are liable to be broadly reliable. In many cases, however, data will need to be collected via household surveys. Data on the total number of children by age and household should be available through national census statistics, though care is needed in relation to the definition of a 'household' (e.g. how collective dwellings are classified).
Level of spatial aggregation	Community or administrative district
Averaging period	Annual or longer term

Computation	The indicator can be computed as a simple percentage: $100 * Cbio / Ctot$ where: *Cbio* is the number of children living in households using coal, wood or dung as the main source of cooking/heating fuel; *Ctot* is the total number of children aged 0-4 years.
Units of measurement	Percentage (or number) or percentage change
Worked example	Assume that, based on a sample survey shows that 9 300 children (from a total of 27 000) live in homes relying on coal, wood or dung as the main fuel source for cooking and heating. The value of the indicator is thus: 100 * 9 300 / 27 000 = 34.4%
Interpretation	This indicator provides a general measure of differences or trends in exposure to air pollutants from indoor heating and cooking sources: a reduction in the percentage of children living in homes relying on coal, wood or dung may be taken to imply a reduced level of exposure and thus a reduced risk of respiratory illness. In applying and interpreting the indicator, however, it should be noted that: • it takes no account of use of other sources of indoor pollution (e.g. smoking, furnishings, solvents); • the indicator takes no account of the many other factors (e.g. lifestyle and ventilation behaviour) likely to affect exposures; • relationships with health outcome may be heavily confounded by other factors, including exposures to outdoor and occupational pollution, housing conditions and socio-economic factors.
Variations and alternatives	Many variations on this indicator are possible, to reflect local circumstances. Different fuel sources or different heating and cooking facilities might be selected, for example, as a basis for the indicator (e.g. 'open fires or unvented gas cookers and heaters' may be more appropriate in more developed areas of the world). Similar indicators can also be designed to include other sources of indoor air pollution, such as asbestos-containing materials, radon-bearing rocks or cements, or homes in which adults smoke. It might also be possible in some cases to score homes according to the presence or absence of several different types of indoor air pollution source, for example: smoking in the home; reliance on coal, wood or dung as the main heating fuel; presence of asbestos-bearing building materials; presence of radon-bearing building materials or underground radon sources. In this case, weights might be used to reflect the differing levels of health risk considered to derive from each source.
Examples	WHO *Environmental health indicators: framework and methodologies* • **Sources of indoor air pollution**
Useful references	Albalak, R., Frisancho, A.R. and Keeler, G.J. 1999 Domestic biomass fuel combustion and chronic bronchitis in two rural Bolivian villages. *Thorax* 54, 1004-8. Bruce, N., Perez-Padilla, R. and Albalak, R. 2000 Indoor air pollution in developing countries: a major environmental and public health challenge.

	Bulletin of the World Health Organization 78, 1078-92. Sharma, S., Sethi, G.R., Rohtagi, A., Chaudhary, A., Shankar, R., Bapna, J.S., Joshi, V. and Sapir, D.G. 1998 Indoor air quality and acute lower respiratory infection in Indian urban slums. *Environmental Health Perspectives* 106, 291-7. Smith. K.R. 1987 *Biomass fuels, air pollution and health. A global review.* New York: Plenum Press. WHO 1999 *Environmental health indicators: framework and methodologies.* Geneva: World Health Organization. (Available at http://www.who.int/docstore/peh/archives/EHIndicators.pdf)

CHILDREN AGED 0-14 YEARS LIVING IN HOUSEHOLDS IN WHICH AT LEAST ONE ADULT SMOKES ON A REGULAR BASIS	
GENERAL CONSIDERATIONS	
Issues	Respiratory diseases
Type of indicator	Exposure (proximal) Can also be used as a measure of action for policies to reduce smoking
Rationale	Exposure to environmental tobacco smoke – perhaps more than any other single factor – is a major threat to children's health. Tobacco smoke contains over 4000 contaminants, many of which are known or suspected carcinogens. Risks come not only as a direct and acute result of inhalation (e.g. respiratory symptoms), but also in the longer term because of increased risks of pulmonary damage, cardiovascular illness and cancer. Smoking in the home also increases the probability that the children themselves will take up the habit, thereby increasing their long-term health risks.
Issues in indicator design	Ideally, an indicator on exposures to environmental tobacco smoke would be based either on suitable biomarkers (e.g. nicotine) or on measurement or modelling of levels of ETS in the home. In practice, both of these are rarely possible because of lack of suitable data. For wider use, therefore, the indicator needs to be based on more accessible information, such as tobacco and cigarette sales or smoking habits (e.g. number of smokers or number of cigarettes smoked). Neither of these provide a wholly accurate measure of levels of exposure. A significant proportion of smoking, for example, takes place outside the home (at work, in the car, outdoors or in leisure venues): in these cases risks of children's exposure are reduced. Even where smoking does take place at home, levels of exposure of children may vary, depending on where within the home it occurs. Information on the number of smokers is also partially misleading, since it takes no account of the level of smoking. Data on numbers of cigarettes smoked, obtained from questionnaires or household surveys, are also commonly found to be somewhat unreliable. For most purposes, therefore, probably the most appropriate indicator – in terms of the availability of data and its reliability – is the percentage of children living in households where at least one adult is a regular smoker. An age range of 0-14 years is proposed for this indicator because risks affect children of all ages. Exposures to ETS are also likely to be greatest during evenings and other periods when most of the adult family members are at home: attendance at school, therefore, does not greatly reduce exposures.
SPECIFICATION	
Definition	Percentage (or number) of children aged 0-14 years old living in households where at least one adult smokes on a regular basis.
Terms and concepts	***Household***: a single dwelling unit (e.g. a house or apartment) intended for permanent residence. ***Adults who smoke on a regular basis***: adults who smoke at least one cigarette, most days (i.e. with an average consumption of about 4 cigarettes or more per week).
Data needs	Number of households in which at least one adult smokes on a regular basis. Total number of children aged 0-14 years, living in these households. Total number of children aged 0-14 years in the survey area.
Data sources,	Data can usually be obtained from household surveys. Questionnaire

availability and quality	surveys (e.g. of children at school) can also be used, as can information from lifestyle surveys.
Level of spatial aggregation	Community, administrative district or region
Averaging period	Annual
Computation	The indicator can be computed as a simple percentage: *100 * Csmoke / Ctot* where: *Csmoke* is the number of children aged 0-14 years living in households with at least one regular smoker; *Ctot* is the total number of children aged 0-14 years in the survey area.
Units of measurement	Percentage or number
Worked example	Assume that, in a survey of 5000 households containing 12'670 children, 6634 are found to be living in households with at least one regular smoker. In this case the indicator value would be: 100 * 6 634 / 12 670 = 52.4 %
Interpretation	This indicator provides a direct and reasonably easily interpretable measure of the potential for children to be exposed to environmental tobacco smoke in the home. Because it takes no direct account of the numbers of smokers in each home, of the quantities of tobacco smoked, or of smoking behaviours (e.g. what proportion takes place in the home, or in the presence of children), interpretation nevertheless needs some care, especially where small-area comparisons are being made.
Variations and alternatives	This indicator can be constructed for different age ranges of children, according to need. Restricting the indicator to younger children (below age 5), as here, has some merit because older children may themselves be smokers and may thus receive large proportions of their exposure either directly, or passively from other children outside the home. Younger children are also especially vulnerable to health risks from ETS. On the other hand, smoking in front of older children seems to be more likely to encourage them, in turn, to smoke. Where the concern is about longer term smoking habits, it may, therefore, be appropriate to extend the age range considered. Other alternatives are also possible, for example, by assessing the numbers of cigarettes to which children may be exposed in the home: in this case, the indicator could be computed as the sum of children * cigarettes smoked in each home. Another possibility, where resources permit, is to use a biomarker such as cotinine in saliva.
Examples	None known
Useful references	Cunningham, J., O'Connor, G.T., Dockery, D.W. and Speizer, F.E. 1996 Environmental tobacco smoke, wheezing, and asthma in children in 24 communities. *American Journal of Respiratory and Critical Care Medicine* 153, 218-24. Di Franza J.R. and Lew, R.A. 1996 Morbidity and mortality in children associated with the use of tobacco products by other people. *Pediatrics* 97, 560-8. Etzel, R.A. 2001 Indoor air pollutants in homes and schools. *Children's Environmental Health* 48, 1153-65.

	Etzel, R.A. 1990 A review of the use of cotinine as a marker of tobacco smoke exposure. *Preventative Medicine* 19, 190-7. Forastiere, F., Corbo, G. M. Michelozzi, P., Pistelli, R., Brancato, G., Ciappi, G. and Perucci, C. A. 1992. Effects of environment and passive smoking on the respiratory health of children. *Journal of Epidemiology 21:66-73.* Hamahan, J. P., Tager, I.B., Segal, M. R. , Stile, R. G., van Vunakii, H. V., Weiss, S. T., and Speizer, F. E. 1992. The effect of maternal smoking during pregnancy on early infant lung function. *American Review of Respiratory Diseases* 145, 1129-1135. Martinez, F.D., Cline, M. and Burrows, B. 19902 Increased incidence of asthma in children of smoking mothers. *Pediatrics* 89, 21-6. Gergen, P.J. 2001 Environmental tobacco smoke as a risk factor for respiratory disease in children *Respiration Physiology* 128, 39-46.

MORTALITY RATE FOR CHILDREN AGED 0-4 YEARS DUE TO ACUTE RESPIRATORY ILLNESS	
GENERAL CONSIDERATIONS	
Issues	Respiratory disease
Type of indicator	Health outcome
Rationale	Acute respiratory illness is one of the main causes of ill health in children. It includes a wide range of effects, including viral and bacterial infection of the lungs and respiratory tracts. It can also be caused or triggered by a large variety of risk factors, especially exposures to air pollution. Low birthweight, malnutrition and overcrowding are also important risk factors. In developing countries, all these risk factors continue to affect large parts of the population, with the result that acute respiratory illness continues to be one of the most ubiquitous forms of childhood morbidity and one of the major causes of death. In more developed countries, on the other hand, changing environmental conditions and improvements in treatment have led to marked changes in the aetiology and distribution of acute respiratory illness in children. In these, levels of traditional air pollutants – such as smoke from wood and coal fires – has declined markedly while levels of overcrowding have also declined. Partly as a consequence, death rates amongst children have fallen. This indicator thus provides a measure of the effects of these various risk factors on children's health
Issues in indicator design	This indicator is perhaps most usefully defined in terms of the reported mortality rate for acute respiratory illness in children aged 0-4 years, since these tend to be the children most at risk. Other age ranges can be used where appropriate. It also needs to be recognized that acute respiratory illnesses tends to be more common in boys than girls. For this reason, it is advisable to standardize the indicator by gender. Acute respiratory illnesses take many forms, so problems may occur in defining precisely the symptoms and illnesses that should be included within the indicator. In some cases, it may be appropriate to limit the indicator to acute respiratory infections (ARI); in others, it may be appropriate to include other acute symptoms, such as wheezing and cough. Differences in diagnosis are likely to affect the reported rates.
SPECIFICATION	
Definition	Annual mortality rate due to acute respiratory infections in children under five years of age.
Terms and concepts	***Acute respiratory infection (ARI):*** an acute infection of the ear, nose, throat, epiglottis, larynx, trachea, bronchi, bronchioles or lung. ***Total number of children aged 0-4 years***: number of live children less than five years of age at the midpoint of the year (or other survey period).
Data needs	Annual number of deaths of children aged 0-4 years due to acute respiratory infections (ARI). Total number of children aged 0-4 years at the mid-point in the survey year.
Data sources, availability and quality	Data on childhood deaths due to ARI are usually available from death registrations, though the quality of these data may vary substantially. Problems occur, especially, in diagnosis, or where formal reporting procedures have not been established. In a number of countries, demographic surveillance surveys include a verbal autopsy module aimed at

	collecting information on the cause of death in children. Information on the number of children aged 0-4 years should be available from national censuses, and should be relatively reliable.
Level of spatial aggregation	Health district
Averaging period	Annual
Computation	The indicator can be computed as a simple mortality rate, per 100 000 children: *100 000 * Dari / Ctot* where: *Dari* is the number of deaths of children aged 0-4 years due to acute respiratory infections; *Ctot* is the total number of children aged 0-4 years.
Units of measurement	Rate per 100 000 children
Worked example	Assume that in an area there are 237 deaths for ARI amongst children aged 0-4 years, from a total population of 162 900 children. In this case, the value of the indicator would be calculated as: 100 000 * 237 / 162 900 = 145.5 deaths per 100 000 children
Interpretation	This indicator may be interpreted to show trends or patterns in mortality due to ARI in young children, as a result of exposure to air pollution in either the home or ambient environment. In this context, an increase in the mortality rate may be taken to infer an increase in exposures; a reduction in mortality may imply a decrease in levels or frequency of exposure. Attribution of deaths to specific environmental exposures or risk factors in this way is, however, difficult. Many different factors influence mortality rates due to ARI. In developing countries, for example, both HIV and malaria are extremely important factors in either causing lower respiratory infection, or presenting as LRI. These may thus have a substantial effect on observed death rates. Mortality is also highly dependent upon the effectiveness of the health care system and availability of treatment; indeed, in many developed countries, mortality rates for acute respiratory illness have remained broadly stable over recent decades, despite a large increase in morbidity.
Variations and alternatives	Where appropriate, this indicator could be defined for other age groups (e.g. children aged 0-14 years). It could also be compiled and presented for other, more specific categories of acute respiratory illness, e.g.: • **Acute lower respiratory infection (ALRI): an acute infection of the larynx, trachea, bronchi, bronchioles or lung.** • **Acute upper respiratory infection (AURI): an acute infection of the nose, pharynx (throat) or middle ear.** In this way, the indicator could be applied to monitor or investigate disease-specific mortality. In developing countries, this might focus on the problem of pneumonia associated with biomass/coal-burning and indoor air pollution. (Typically this will comprise a high proportion of deaths due to acute respiratory illness in these countries.) In developed countries the growing problem of asthma associated with vehicle air pollution may prompt use of asthma-specific indicators.
Examples	WHO *Catalogue of health indicators* • **Under-five deaths due to acute respiratory infections**

	• **WHO Environmental health indicators: framework and methodologies** • **Childhood mortality due to acute respiratory illness** WHO *Environmental health indicators for the European region* • **Mortality rate due to respiratory diseases in children > 1 month and < 1 year of age** World Bank *HNP Indicators on Socio-Economic Inequalities* • **Prevalence of ARI**
Useful references	Garenn, M., Ronsmans, C. and Campbell, H. 1992 The magnitude of mortality from acute respiratory infection in children under 5 years in developing countries. *World Health Statistics Quarterly* 45, 180-91. WHO 1992 *The measurement of overall and cause specific mortality in infants and children*. Report of joint World Health Organization/UNICEF Consultation, 15-17 December 1992. WHO 1994 *The management of acute respiratory infections in children. Practical guidelines for outpatient care*. Geneva: for the Control of Diarrhoea and Acute Respiratory Diseases, World Health Organization. WHO 1996 *Catalogue of health indicators: a selection of health indicators recommended by WHO programmes*. Geneva: World Health Organization (under revision). WHO 1999 *Environmental health indicators: framework and methodologies.* Geneva: World Health Organization. (Available at http://www.who.int/docstore/peh/archives/EHIndicators.pdf) WHO 2002 *Environmental health indicators: development of a methodology for the WHO European region.* Bonn: World Health Organization.

MORBIDITY RATE FOR CHILDREN AGED 0-4 YEARS DUE TO ACUTE RESPIRATORY ILLNESS	
GENERAL CONSIDERATIONS	
Issues	Respiratory disease
Type of indicator	Health outcome
Rationale	Acute respiratory illness is one of the main causes of ill health in children. It includes a wide range of effects, including viral and bacterial infection of the lungs and respiratory tracts. It can also be caused or triggered by a large variety of risk factors, especially exposures to air pollution. Low birthweight, malnutrition and overcrowding are also important risk factors. In developing countries, all these risk factors continue to affect large parts of the population, with the result that acute respiratory illness continues to be one of the most ubiquitous forms of childhood morbidity and one of the major causes of death. In more developed countries, on the other hand, changing environmental conditions and improvements in treatment have led to marked changes in the aetiology and distribution of acute respiratory illness in children. In these, levels of traditional air pollutants – such as smoke from wood and coal fires – has declined markedly; levels of overcrowding have also declined, while nutrition has generally improved. As a result, in developed countries, bacterial pneumonia has also declined. On the other hand, smoking has declined less sharply, while other sources of pollution (e.g. road traffic) and exposures to dust mite and other domestic risk factors have in many cases increased. Diseases of the upper respiratory tract, such as asthma, wheezing, hay fever and allergic rhinitis, have therefore increased in many countries.
Issues in indicator design	This indicator is perhaps most usefully defined in terms of the reported incidence of acute respiratory illness in children aged 0-4 years, since these tend to be the children most at risk. Other age ranges can be used where appropriate. It also needs to be recognized that acute respiratory illnesses tends to be more common in boys than girls. For this reason, it is advisable to standardize the indicator by gender. Like other morbidity-based indicators, however, the indicator faces particular problems because of the lack of, or uncertainties in, the available data. Most cases of acute respiratory illness are short-lived, self-limiting and mild, and can be treated (if needed) with over-the- counter medicines. Only the more severe cases, therefore, tend to be reported, and rates of reporting depend on the availability of, and access to, the health services. Acute respiratory illnesses take many forms, so problems also occur in defining precisely the symptoms and illnesses that should be included within the indicator. In some cases, it may be appropriate to limit the indicator to acute respiratory infections (ARI); in others, it may be appropriate to include other acute symptoms, such as wheezing and cough. Differences in diagnosis are likely to affect the reported rates.
SPECIFICATION	
Definition	Incidence of morbidity due to acute respiratory infections in children aged 0-4 years.
Terms and concepts	***Acute respiratory infection (ARI):*** an acute infection of the ear, nose, throat, epiglottis, larynx, trachea, bronchi, bronchioles or lung. ***Total number of children aged 0-4 years***: number of live children aged 0-4

	years at the midpoint of the year (or other survey period).
Data needs	Number of cases of acute respiratory infection (ARI) in children aged 0-4 years. Total number of children aged 0-4 years.
Data sources, availability and quality	Data on the number of cases of acute respiratory infection amongst young children may be obtainable from a number of different sources, including hospital admissions, GP records and household surveys. None of these sources is comprehensive and wholly free of bias, and GP data are difficult to acquire. For most purposes, therefore, the best available data are likely to come either from hospital admissions records or by household surveys. The former includes only the more severe cases, and will omit cases which are not referred to hospital (e.g. which are treated at home or by the GP). Household surveys tend to be based on relatively small samples, and may also suffer from bias or inconsistency in reporting. Data on the total number of children aged 0-4 years are available from national census statistics, and should be reliable, especially for census years. Inter-censual estimates may be made using vital registration data or demographic models, but may contain some uncertainties due to effects of migration. These are likely to be significant only at the small area scale.
Level of spatial aggregation	Health district
Averaging period	Annual
Computation	The indicator can be computed as a simple rate (per thousand children): *1 000 * Mari / Ctot* where: *Mari* is the total number of cases of acute respiratory infection in children aged 0-4 years in the survey period (e.g. the last calendar year); *Ctot* is the total number of children aged 0-4 years at the mid-point of that survey period.
Units of measurement	Number per thousand children aged 0-4 years.
Worked example	Assume that, in one year, there were 1 300 reported cases of ARI in an area containing 47 000 children aged 0-4 years. In this case, the indicator value would be: 1 000 * 1 300 / 47 000 = 27.7 cases per 1 000 children.
Interpretation	This indicator is intended to provide a measure of changes or differences in the incidence of acute respiratory infections, as a result of exposure to air pollution in either the home or ambient environment. In this context, an increase in the morbidity rate may be taken to infer an increase in exposures; a reduction in morbidity may imply a decrease in levels or frequency of exposure. In practice, however, such interpretations are problematic. Exposure to air pollution is only one of many possible causes of acute respiratory infection; other risk factors include nutrition, diet, micronutrient intake and birth weight. Data on morbidity are also limited and often inconsistent, making comparisons between different countries or interpretations of trends potentially difficult. Many cases go unreported. Differences in the structure of the health service (e.g. the extent of provision of asthma clinics) and in

	diagnosis also affect the reported rates. Attempts to combine statistics from different sources pose difficulties because of differences in classification and possible double-counting of individual cases. As with all morbidity measures, therefore, this indicator needs to be interpreted with care.
Variations and alternatives	Variations on this indicator are possible, depending on the availability of morbidity data and on the intended application. The indicator can, for example, be calculated for different age ranges (e.g. 0-1 year olds). In some countries, sales of respiratory medication (e.g. inhalers) can be used as a proxy, though this is non-specific to this age group; registrations at asthma clinics may also provide a proxy. The indicator could also be compiled and presented for other, more specific categories of acute respiratory illness, e.g.: • acute lower respiratory infection (ALRI): an acute infection of the larynx, trachea, bronchi, bronchioles or lung; • acute upper respiratory infection (AURI): an acute infection of the nose, pharynx (throat) or middle ear.
Examples	WHO *Environmental health indicators: framework and methodologies* • **Childhood morbidity due to acute respiratory illness** WHO *Catalogue of health indicators* • **Care-seeking for children with acute respiratory infections**
Useful references	WHO 1992 *The measurement of overall and cause specific mortality in infants and children*. Report of joint WHO/UNICEF Consultation, 15-17 December 1992. WHO 1994 *The management of acute respiratory infections in children. Practical guidelines for outpatient care.* Geneva: for the Control of Diarrhoea and Acute Respiratory Diseases, World Health Organization. WHO 1996 *Catalogue of health indicators: a selection of health indicators recommended by WHO programmes*. Geneva: World Health Organization (under revision). WHO 1999 *Environmental health indicators: framework and methodologies.* Geneva: World Health Organization. (Available at http://www.who.int/docstore/peh/archives/EHIndicators.pdf)

PREVALENCE OF CHRONIC RESPIRATORY ILLNESSES IN CHILDREN AGED 0-14 YEARS	
GENERAL CONSIDERATIONS	
Issues	Respiratory diseases
Type of indicator	Health outcome
Rationale	Long-term exposure to air pollution, both in the home and outdoors, is known to increase the risk of chronic respiratory illness in children. Probably the most important exposures are to environmental tobacco smoke, but in many developing countries domestic cooking and heating are also serious sources of exposure. Ambient air pollution, from industry and – increasingly – road traffic, as well as exposures to a wide range of other indoor risk factors, such as pets, house dust and dust mite, are also important in some populations. These various exposures contribute – along with a wide range of other factors – to several chronic illnesses in children, including asthma, chronic bronchitis, chronic obstructive airways disease (COAD) and emphysema.
Issues in indicator design	This indicator can be expressed as the prevalence of chronic respiratory diseases in children aged 0-14 years. This age range is chosen because risks tend to persist throughout the child's life (though often in response to differing risk factors). Chronic respiratory illnesses may be taken to include asthma, chronic bronchitis, chronic obstructive airways disease (COAD) and emphysema. Possibly the most important issue in this case is the difficulty in obtaining reliable data on the prevalence of these diseases in children. Problems arise both because of inconsistencies in diagnosis and because of variations in referral and reporting rates.
SPECIFICATION	
Definition	Prevalence of chronic respiratory diseases amongst children aged 0-14 years.
Terms and concepts	***Chronic respiratory diseases***: asthma, chronic cough, chronic bronchitis, emphysema and chronic obstructive airways diseases.
Data needs	Reported rate of chronic respiratory diseases amongst children aged 0-14 years. Total number of children aged 0-14 years.
Data sources, availability and quality	The main data sources for information on the prevalence of chronic respiratory diseases are likely to be routine reporting systems from hospitals (e.g. hospital admissions or discharge records) or through household surveys. Data may also be available in some cases from GPs or specialist clinics (e.g. asthma clinics). All these data, however, need to be used with care, because of inconsistencies over both time and space due to differences in referral practices, diagnosis, reporting rates and coding. Data on the total number of children aged 0-14 years should usually be available from national censuses and should then be reliable. Estimates for inter-censual years (or where census data are not available) may be made using population models or from births and deaths data.
Level of spatial aggregation	Community or health district
Averaging	Annual

period	
Computation	The indicator can be computed as: 1000 * *Mcri / Ctot* where: *Mcri* is the number of children aged 0-14 years reported to have experienced chronic respiratory illness over the previous year; *Ctot* is the total number of children aged 0-14 years at the midpoint of the study year.
Units of measurement	Number per 1 000 children
Worked example	Assume that, in one area, there are 4 562 reported cases of chronic respiratory illness during one year, amongst a population of 33 960 children aged 0-14 years. In this case, the indicator value is: 1 000 * 4 562 / 33 960) = 134.3 cases per 1 000 children
Interpretation	This indicator can be interpreted as a measure of the prevalence of chronic respiratory illnesses in children. Because environmental factors such as exposures to environmental tobacco smoke, indoor air pollution and ambient air pollution account for a large proportion of these diseases, an increase in the indicator implies a worsening of these environmental conditions, while a reduction in the indicator implies an improvement. Care is, nevertheless, required in interpreting the indicator because many other factors are implicated in chronic respiratory illness in young children, including inherited characteristics, birth defects, infections and a wide range of lifestyle factors (e.g. drug usage and diet). As with almost all morbidity indicators, also, considerable inaccuracies and inconsistencies may occur in the available data, making comparisons over time or space difficult.
Variations and alternatives	Several alternatives to and variations on this indicator are possible. For some applications, for example, it may be more appropriate to restrict the indicator to a narrower range of health outcomes, such as asthma and chronic cough, or chronic bronchitis: the choice of outcome should ideally reflect the exposures considered to be operative. The indicator may also be applied to a narrower age range of children (e.g. 0-4 years), since above an age of about 9-11, various factors (such as smoking behaviour) may make the indicator more difficult to interpret. Where data on chronic disease prevalence are not available, proxies may be developed, for example using data on usage or sales of bronchodilators. If resources permit, it may also be possible to base the indicator on biomarker data (e.g. from skin prick tests) or measurements of lung function (e.g. FEV). The prevalence period used to compute the indicator can also be varied – e.g. to cover the child's whole life. As the prevalence period is extended, however, increasing problems of data reliability are likely to occur if the data are obtained from surveys requiring 'recall' (e.g. by parents).
Examples	None known

Useful references	Äit-Khaled, N. Enarson, D. and Bousquet, J. 2001 Chronic respiratory diseases in developing countries: the burden and strategies for prevention and management. *Bulletin of the World Health Organization* 79, 971-9. Strachan, D.P. and Carey, I.M. 1995 Home environment and severe asthma in adolescence: a population based case-control study. *British Medical Journal* 311 1053-6. Strachan, D.P., Anderson, H.R., Limb, E.S., O'Neill, A. and Wells, N. 1994 A national survey of asthma prevalence, severity and treatment in Great Britain. *Archives of Disease of Children* 70, 174-8. Von Mutius, E., Weiland, S.K., Fritzsch, C., Duhme, H. and Keil, U. 1998 Increasing prevalence of hay fever and atopy among children in Leipzig, East Germany. *Lancet* 351, 862-6.

ATTRIBUTABLE CHANGE IN TOBACCO CONSUMPTION	
GENERAL CONSIDERATIONS	
Issues	Respiratory disease
Type of indicator	Health outcome
Rationale	Exposure to environmental tobacco smoke – perhaps more than any other single factor – is a major threat to children's health. Tobacco smoke contains over 4000 contaminants, many of which are known or suspected carcinogens. Risks come not only as a direct and acute result of inhalation (e.g. respiratory symptoms), but also in the longer term because of increased risks of pulmonary damage, cardiovascular illness and cancer. Smoking in the home also increases the probability that the children themselves will take up the habit, thereby increasing their long-term health risks. Action to reduce smoking is therefore one of the most important and potentially effective ways of improving children's respiratory health – as well as reducing other longer-term health risks.
Issues in indicator design	In so far as action to reduce smoking is successful, it is likely to be reflected in a reduction in tobacco and cigarette sales and smoking habits (e.g. number of smokers or number of cigarettes smoked). Reliable information on smoking habits is difficult to acquire, but data on tobacco and cigarette sales and on population numbers can be used to track changes in the level of tobacco consumption. Comparing sales after policy intervention with predicted sales derived by extrapolating data from before the policy was introduced gives an indicator of the success of the policy.
SPECIFICATION	
Definition	Attributable changes in tobacco sales per adult
Terms and concepts	***Tobacco sales:*** number of cigarettes (or equivalent in tobacco) sold by year ***Total number of adults:*** number of people aged 15 years or more
Data needs	Tobacco sales Number of people aged 15 years or more
Data sources, availability and quality	Data on tobacco sales can be obtained from a number of sources, including tobacco companies, taxation agencies or retailers. These data are likely to be broadly reliable, though some under-reporting is likely due to sales on the informal market. Where sales data are not available, estimates may be made on the basis for surveys either of consumers or retailers. Data on population numbers should be available from national censuses and should then be reliable. Estimates for inter-censual years (or where census data are not available) may be made using population.
Level of spatial aggregation	Region
Averaging period	Annual

Computation

The indicator can be computed as the percentage change in the sales of tobacco per adult before and after intervention, over and above any change that would have occurred without intervention. This is done by finding the difference between tobacco purchases after intervention and the projected sales based on a 'no-intervention' scenario. Three steps are involved in the process of the indicator development.

First the trend in annual sales per head of population should be computed for the pre-intervention period. This is best done using regression analysis methods (as available in most statistical packages and spreadsheets such as Excel). This provides a formula that can be used to predict sales in the post-intervention period. If no trend is observable (i.e. if the association with time is statistically not significant at the 95% level), then the arithmetic average from the pre-intervention period should be used. Alternatively, it may be possible to derive a trend 'by eye' by graphing the data as a scattergram and interpolating a trend line. Whichever method is used, attention should be paid to the nature of the relationship; in the event of a strongly non-linear trend, for example, an appropriate curvilinear trendline should be fitted, either by transforming the data or by using polynomial curve-fitting functions.

Using the fitted trend, sales for the period after policy intervention should then be calculated, by projection of the trendline, and taking account of any population change. Values for each year since intervention should be computed.

Finally, the reported sales post-intervention are compared with the projected sales per adult and the differences calculated. The indicator is expressed as the percentage difference, compared with the projected sales, as follows:

$$100 * \Sigma(Sales_{rpost} - Salesl_{proj}) \; / \; \Sigma \, (Salesl_{proj})$$

where: $Sales_{proj}$ is the projected volume of tobacco sales during the post-intervention period;

$Sales_{post}$ is the reported volume of tobacco sales during the post-intervention period.

Units of measurement

Percentage change

Worked example

A worked example is presented in the table below. In this case, an intervention in the year 1999, aimed at reducing sales, is assessed using an indicator of sales over the following five years.

Year	Actual			Projected	
	Volume	Pop (million)	Sales rate	Post-sales rate	Volume
1994	47	14	3.36		
1995	50	14.1	3.55		
1996	48	14.2	3.38		
1997	54	14.3	3.78		
1998	53	14.4	3.68		
1999					
2000	51	14.5	3.52	3.91	56.70
2001	49	14.6	3.36	4	58.37
2002	50	14.7	3.4	4.09	60.06
2003	49	14.8	3.31	4.17	61.76
2004	50	14.9	3.36	4.26	63.49
Total (post)	**249**				**300.36**

	In this case, analysis of the sales rate (per head of population) for the pre-intervention years (1994-1998) gives a positive trend, with the formula: *Sales rate = (0.0877*Year) – 171.49* In the fifth column of the table, this rate has been applied to predict the sales rate without intervention, taking account of the number of inspections made, and this is then used to recalculate the total expected sales in each of these years, allowing for the population size (column 6). The differences between the total actual sales over the post-intervention period and the total projected sales for the same period (as a percentage of the projected sales) is then calculated to represent the indicator: i.e. 100 *(249 – 300.36) / 300.36 = -17.1% - i.e. a reduction of 17.1% in the expected tobacco sales.
Interpretation	This indicator provides a measure of the rate of change in cigarette and tobacco consumption by adults. It thus indicates the success, or otherwise, of policies aimed at reducing cigarette and tobacco consumption. A negative value of the indicator implies that policies are effectively reducing average levels of consumption; a positive value implies that policies are not reducing consumption levels. Several factors nevertheless need to be kept in mind in interpreting the indicator. Changes do not only reflect the effects of policy: other factors, such as population numbers, changing age or gender profiles, and changes in levels of disposable income may also affect consumption. Problems of data reliability also need to be considered, especially where there is a significant informal market for cigarettes and tobacco. Care is therefore needed in attributing changes to specific policy measures.
Variations and alternatives	Where policies to reduce tobacco consumption are introduced in only part of the area of interest, this indicator can be improved, by comparing trends before and after intervention in the intervention area (i.e. where the policy has been applied) with trends before and after intervention in a matched control area (one with similar consumption characteristics but in which the policy has not been applied).
Examples	None known
Useful references	Cunningham, J., O'Connor, G.T., Dockery, D.W. and Speizer, F.E. 1996 Environmental tobacco smoke, wheezing, and asthma in children in 24 communities. *American Journal of Respiratory and Critical Care Medicine* 153, 218-24. DiFranza J.R. and Lew, R.A. 1996 Morbidity and mortality in children associated with the use of tobacco products by other people. *Pediatrics* 97, 560-8. Etzel, R.A. 2001 Indoor air pollutants in homes and schools. *Children's Environmental Health* 48, 1153-65. Etzel, R.A. 1990 A review of the use of cotinine as a marker of tobacco smoke exposure. *Preventative Medicine* 19, 190-7. Forastiere, F., Corbo, G. M. Michelozzi, P., Pistelli, R., Brancato, G., Ciappi,

	G. and Perucci, C. A. 1992. Effects of environment and passive smoking on the respiratory health of children. *Journal of Epidemiology 21:66-73.* Hamahan, J. P., Tager, I.B., Segal, M. R. , Stile, R. G., van Vunakii, H. V., Weiss, S. T., and Speizer, F. E. 1992. The effect of maternal smoking during pregnancy on early infant lung function. *American Review of Respiratory Diseases* 145, 1129-1135. Martinez, F.D., Cline, M. and Burrows, B. 1992 Increased incidence of asthma in children of smoking mothers. *Pediatrics* 89, 21-6. Gergen, P.J. 2001 Environmental tobacco smoke as a risk factor for respiratory disease in children *Respiration Physiology* 128, 39-46.

ATTRIBUTABLE CHANGE IN ATMOSPHERIC POLLUTANT CONCENTRATIONS	
GENERAL CONSIDERATIONS	
Issues	Respiratory diseases
Type of indicator	Health outcome
Rationale	Action to reduce children's exposure to ambient air pollution can take many forms. Common policy tools include air quality standards, emissions limits, environmental taxes, subsidies for clean technologies, land use planning, and controls on polluting fuels, products or processes. Which is the most appropriate is likely to vary from one place (and one time) to another, depending on the types and sources of pollution concerned, and the policy, socio-economic and environmental context. How effective any measure is will also depend on how well it is implemented and enforced. Indicators that simply describe the existence or scope of specific policy actions are, therefore, likely to give only a partial picture of the success or otherwise of intervention. More useful is to measure the effects of these measures. One way of doing this is to monitor changes in health outcome. Since many factors other than air pollution affect rates of respiratory illness, however, effects of intervention are often difficult to detect. They may also not become apparent for many years. A more sensitive and earlier indication of the effectiveness of policy intervention is thus given by monitoring the changes in ambient air pollution concentrations that can be attributed to policy intervention.
Issues in indicator design	A number of design issues have to be addressed in developing this indicator. Probably the most important is the choice of pollutant(s). Many different pollutants may affect respiratory health, including fine particulates, nitrogen oxides (NO_x, NO_2), sulphur dioxide (SO_2) and ozone (O_3). Which is the most important may vary, depending on the character of pollution sources (e.g. the level of industrialization, the road vehicle mix). Choosing only one pollutant may therefore be limiting – though in general terms fine particles are probably the most important and possibly give the best general marker. Where possible, however, it is better to design this indicator to measure changes in all the relevant pollutants. This has the particular advantage of ensuring that pollutant substitution (i.e. increases in one pollutant as a result of a reduction in emissions of another) does not lead to spurious improvements in the indicator. In this case, some form of pollutant index needs to be developed. A second problem concerns the availability of data. Monitoring networks for air pollutants are sparse in most countries, and are rarely fully representative of population exposures. Differences also occur, both from country to country and from one city or region to another, in the types of pollutants measured and the monitoring techniques used. This can make comparisons between different areas difficult. Ideally, the indicator should reflect the availability and quality of the monitored data. A third design question is the averaging period to be used. In most cases, the annual average concentration (calculated by averaging daily or hourly values across the whole year) is the most appropriate. Where strong seasonal or shorter term variations in pollution occur, however, it may be more meaningful to use different averaging periods, or to design the indicator in terms of the peak concentrations, or number of days exceeding a specified threshold.

	Finally, there is the issue of how to assess the attributable component of any change in air pollution concentrations. Not all the changes that occur can necessarily be attributed to intervention; in some cases, intervention may be having a bigger effect than immediately apparent, because – without it – air pollution would have got much worse. The real need is thus to compare changes in air pollutant concentrations after intervention with those that would have occurred without the intervention. This can be done in one of two ways: either by extrapolating pre-intervention trends to the period after intervention, and calculating the difference; or by comparing difference before and after intervention in 'target' areas where the policy is implemented, with matched 'control' areas where no intervention has occurred.
SPECIFICATION	
Definition	Attributable annual change in average annual concentrations of PM_{10}, SO_2, NO_2 and O_3
Terms and concepts	***Average annual pollutant concentration:*** the mean concentration of the specified pollutant averaged over a year; adjustment may be necessary in computing the average to take account of gaps in the data, or discontinuities in monitoring.
Data needs	Daily (or hourly) concentrations of PM_{10}, SO_2, NO_2 and O_3 for the base year and current (or latest) year at a representative sample of monitoring stations.
Data sources, availability and quality	Data on air pollutant concentrations are usually obtainable from national or municipal monitoring networks. The range of pollutants measured, their exact definition, monitoring techniques and protocols and siting characteristics may all vary, however so, data may need to be screened to identify the most representative sites. Where possible, sites reflecting residential areas, or other areas in which children may be expected to receive significant exposures, should be selected. Information on the completeness of data capture (e.g. numbers of valid measurements) should also be collected and used to ensure that the data provide reliable estimates of the mean annual concentration.
Level of spatial aggregation	Municipality or region
Averaging period	Annual
Computation	The indicator is computed as the additional change in air pollution (as a percentage) over and above that which would have occurred without intervention. This is achieved by finding the difference between the standardized pollutant concentrations after intervention and the projected concentrations based on a 'no-intervention' scenario. Four steps are involved in the process of indicator development. First, a standardized measure of the air pollutant concentration across all sites ($Pmean_y$) in each year should be computed for each pollutant. If appropriate, sites may be weighted in this process according to their geographical representativeness (e.g. to avoid over-influence from local clusters of sites), as follows: $\Sigma [(Wsite_i * Pdays_i / Ndays) / Nsite]_y$ where: $Wsite_i$ is the weight given to site (default = 1); $Pdays_i$ is the daily concentration of the pollutant at site *i*; $Ndays_i$ is the number of days for which monitoring is available at site *i*; *Nsite* is the number of sites The trend in annual standardized concentrations should then be computed for the pre-intervention period for each pollutant. This is best done using

regression analysis methods (as available in most statistical packages and spreadsheets such as Excel). This provides a formula that can be used to predict concentrations in the post-intervention period. If no trend is observable (i.e. if the association with time is statistically not significant at the 95% level), then the arithmetic average from the pre-intervention period should be used. Alternatively, it may be possible to derive a trend 'by eye' by graphing the data as a scattergram and interpolating a trend line. Whichever method is used, attention should be paid to the nature of the relationship; in the event of a strongly non-linear trend, for example, an appropriate curvilinear trendline should be fitted, either by transforming the data or by using polynomial curve-fitting functions.

Using the fitted trend, standardized concentrations for each pollutant for the period after policy intervention should then be calculated, by projection of the trendline. Values for each year since intervention should be computed.

Finally, the monitored standardized concentrations are compared with the projected concentrations and the differences calculated. The indicator is expressed as the percentage difference, compared with the projected concentrations, as follows:

$$100 * \Sigma\ [\Sigma(Pmean_{post} – Pmean_{proj})\ /\ \Sigma(Pmean_{proj})]_x\ /\ Npoll]$$

where: $Pmean_{proj}$ is the projected mean annual standardized concentration of the pollutant based on extrapolation from the pre-intervention concentrations;

$Pmean_{post}$ is the mean annual concentration of pollutant in the post-intervention year;

x is the pollutant;

$Npoll$ is the number of pollutants.

Units of measurement

Percentage change

Worked example

Assume that the indicator is being computed on the basis of three pollutants (PM_{10}, NO_2 and SO_2). Assume that the annual concentrations of these in the five years before, and the five years after policy intervention were as shown in the Table below:

Year	SO2	PM10	NO2
1994	35	50	60
1995	28	53	62
1996	32	48	70
1997	30	52	66
1998	25	49	70
Intervention			
2000	24	44	70
2001	20	47	63
2002	16	38	60
2003	25	45	64
2004	18	35	58

When analysed using regression analysis, the relationships with year are as follows:

SO_2: $Pmean_{proj} = 3622.8 – 1.8*Year$

	PM_{10}: $Pmean_{proj}$ = 50.4 (no statistical trend = average of Pmeanpre NO_2: $Pmean_{proj}$ = -4724.8 + 2.4*Year When used to predict concentrations in the five post-intervention years these give the following estimates: Year SO_2 PM_{10} NO_2 2000 24.6 50.4 72.8 2001 22.8 50.4 75.2 2002 21.0 50.4 77.6 2003 19.2 50.4 80.0 2004 17.4 50.4 82.4 The actual values are then subtracted from these projections to give the differences, year by year: Year SO_2 PM_{10} NO_2 1999 -0.6 -6.4 -2.8 2000 -2.8 -3.4 -12.2 2001 -5.0 -12.4 -17.6 2002 5.8 -5.4 -16.0 2003 0.6 -15.4 -24.4 These differences are then summed for each pollutant, to give the total difference over the five years, and divided by the sum of the projected concentrations for the same five years. The resulting values are then summed and converted to a percentage. For SO_2, PM_{10} and NO_2, respectively, this gives: 100 * [(-2/105) + (-43/252) + (-73/388)] = -12.6% i.e. a 12.6% reduction in expected air pollution concentrations.
Interpretation	This indicator can be interpreted as a measure of the change in ambient air pollution as a result of policy and other interventions. A positive value for the indicator implies that these interventions are failing to improve air quality; a negative value implies that these interventions are succeeding in improving air quality. For several reasons, however, such interpretations need to be interpreted with care. One reason is that policy interventions are not the only factor that may influence changes in ambient air pollution levels: short term variations in economic activity and year to year changes in weather conditions may also be important. Use of a control zone to standardize the indicator, and averaging over several years, help to minimize these effects but residual may still exist. Changes in the distribution of monitoring stations within the network also need to be taken into account, as do changes in measurement methods and the issues of data quality.
Variations and alternatives	Where policies have been introduced in only part of the area of interest, this indicator can be refined by comparing trends before and after intervention in the intervention area (i.e. where the policy has been applied) with trends before and after intervention in a matched control area (one with similar pollution characteristics but in which the policy has not been applied). The indicator can also be formulated in terms of average population of exposure. This has the advantage of providing a measure which is more directly targeted at the risks to children's health. It requires calculating a

	population-weighted measure of exposure by intersecting the monitored data with data on population distribution. The problem with this approach is that there may be large uncertainties in the assumptions about, or models of, pollution patterns. These may more than outweigh the year-to-year variations in ambient pollution levels. Another alternative is to measure the indicator in terms of emissions rather than ambient concentrations. This has the advantage of providing an even earlier warning of the effects of intervention. However, it suffers from the disadvantage that many emissions, especially those from large combustion sources, may not contribute to local pollution or exposures, but instead be dispersed in the high atmosphere. It therefore tends to accentuate industrial areas rather than residential areas as the main sources of concern. In addition, the different pollutants can be weighted according to their relative toxicity.
Examples	None known
Useful references	WHO Healthy Cities Air Management Information System (AMIS): http://www.who.int/environmental_information/Disburden/Articles/schwela.pdf

ATTRIBUTABLE CHANGE IN NUMBER OF HOUSEHOLDS RELYING ON BIOMASS FUELS OR COAL AS THE MAIN SOURCE OF HEATING AND COOKING	
GENERAL CONSIDERATIONS	
Issues	Respiratory diseases
Type of indicator	Action
Rationale	Children spend a large proportion of their time indoors, either at home or at school. Levels of air pollution in the indoor environment are therefore important determinants of exposure to air pollutants, and thus of children's health. Short periods of high level exposures are known to be implicated in acute respiratory responses (e.g. reduced lung function, wheezing, asthma attacks). Sensitization to air pollution at an early age may also increase long-term susceptibility to air pollution and contribute to risks of chronic health effects in later life. Much of the pollution found indoors derives from outdoor sources; indoor concentrations thus depend in part on outdoor concentrations, and much of this derives from indoor combustion sources. Combustion of biomass fuels in unvented (or poorly vented) stoves and fires for cooking and heating often represents the most important indoor source (together with smoking). Pollutants emitted include particles, carbon monoxide, sulphur dioxide, nitrogen dioxide and volatile organic compounds (of which a number are known or suspected carcinogens). In poorly vented environments, particles and carbon monoxide are often found at especially high levels and pose particular health threats. Potential health effects include acute respiratory infection, chronic pulmonary disease, cancer, tuberculosis, reduced birthweight and eye-damage. Actions to reduce exposures from indoor combustion sources may take many forms. Depending on circumstances, they might include local initiatives to set up woodland schemes (in order to substitute firewood for dung), help to make available improved stoves and heating appliances, changes in taxation policies on domestic fuels or installation of electricity or gas supplies. If successful, these schemes should result in the reduction of the number of households reliant on highly polluting combustion sources, and thus in the number of children exposed.
Issues in indicator design	As with other measures of action, this indicator should ideally be focused on monitoring the degree of success of the actions, rather than simply the action itself. For this reason, the preferred indicator is not one that reports on the existence or extent of policies to reduce exposures to indoor air pollution, but instead measures changes in exposures as a result of these policies. If the relevant information were available, this could be based on monitoring of air pollution in the indoor environment. Such data are, however, generally lacking. In practice, they may also be difficult to interpret because of the many other factors that contribute to indoor air pollution. In most cases, therefore, the effectiveness of actions targeted at indoor combustion sources are best computed in terms of changes in the character of those sources. The specific sources involved may vary, depending on the scope and purpose of the action (e.g. whether it is aimed at all biomass sources, or only at dung or wood). In general terms, however, the indicator can be designed to measure changes in the number or percentage of children exposed to the combustion sources of interest. The indicator may be developed either to monitor changes in the extent of exposure over time, as a result of the introduction of the policies, or to compare areas in which action has been taken with those in which it has not. In both these cases, however,

	interpretation can be difficult, because changes may be confounded by other events or other differences between the study areas. Ideally, therefore, the indicator should be measured by comparing rates of change in an 'intervention area' (before and after the intervention) with those in a matched 'control area' (a similar areas in which the intervention has not been carried out).
SPECIFICATION	
Definition	Attributable change in the percentage (or number) of children aged 0-4 years living in households using coal, wood or dung as the main source of heating and cooking fuel.
Terms and concepts	***Household*:** a single dwelling unit (e.g. a house or apartment) intended for permanent residence. ***Use of coal, wood or dung as the main source of cooking or heating*:** the reliance on coal (or lignite), wood or dung as the primary cooking or heating fuel in the home. ***Attributable change:*** the percentage (or number) of fewer or additional children potentially exposed (i.e. living in households using coal, wood or dung as the main source of heating and cooking fuel) as a direct or indirect consequence of the intervention.
Data needs	Number of children aged 0-4 years by type of fuel usage in the home before and after policy intervention in both the intervention area and a matched control area.
Data sources, availability and quality	Data on number of households using coal, wood or dung as the main source of cooking and heating fuel may be available from census statistics or household surveys, and in these cases are liable to be broadly reliable. In many cases, however, data will need to be collected via household surveys. Surveys should ideally be held immediately before and some time after the intervention, in order to ensure that any long term effects and adjustments are taken into account. Where different areas are to be compared, it is important to find matched areas that were as similar as possible before intervention, and to ensure that – apart from the intervention itself – they otherwise remain similar thereafter. Data on the total number of children by age and household should be available through national census statistics, though care is needed in relation to the definition of a 'household' (e.g. how collective dwellings are classified). Alternatively, they can be obtained for a sample of households as part of the household survey.
Level of spatial aggregation	Community or administrative district
Averaging period	Annual or longer term
Computation	The indicator can be computed as the percentage difference in the rates of change between the intervention and control areas, as follows: $100 * \{[(Cbio/Ctot)_t – (Cbio/Ctot)b]_i / n_i\} – \{[(Cbio/Ctot)_t – (Cbio/Ctot)b)_c\} / n_c$ where: *Cbio* is the number of children living in households using coal, wood or dung as the main source of cooking/heating fuel; *Ctot* is the total number of children aged 0-4 years *t* = current year and *b* = baseline (pre-intervention) year *i* = intervention area; c = control area *n* = number of years between current and baseline surveys

Units of measurement	Percentage change
Worked example	Assume that, for the intervention area, the baseline (pre-intervention) survey shows that 380 children from a sample of 1400 live in homes relying on coal, wood or dung as the main fuel source for cooking and heating, whilst the current (post-intervention) survey, five years later shows that 270 from a sample of 1300 children now live in homes relying on coal, wood or dung as the main fuel source for cooking and heating. Assume, also, that for the matched control area, the pre-intervention survey showed that 450 children from a sample of 1600 lived in homes relying on coal, wood or dung as the main fuel source for cooking and heating, while the post-intervention survey, seven years later) showed that 420 from a sample of 1620 children live in homes relying on coal, wood or dung as the main fuel source for cooking and heating. The value of the indicator is thus: 100 *{[(270/1300) – (380/1400)/ 5] - [(420/1620) – (450/1600)/7] = 100* [(0.207-0.271)/5] – [(0.259 - 0.281)/7] = 100 * (-0.012 – -0.003) = -0.9 (i.e. a 0.9% per year reduction in potential exposure attributable to the intervention)
Interpretation	This indicator provides a general measure of changes in potential exposure to air pollutants from indoor heating and cooking sources as a result of policy or other actions. A positive value indicates that the proportion of children potentially exposed has increased; a negative value indicates a reduction in potential exposure (and thus a reduced risk of respiratory illness). The extent to which these changes can be truly attributable to the intervention does, of course, need to be interpreted with caution. Many other events may contribute to the measured change, and if these are acting differentially between the intervention and control area they can seriously bias the indicator. Careful selection of the control area is essential to minimize this risk.
Variations and alternatives	As described above, this indicator requires before and after surveys in both the intervention area and a matched control area. For various reasons this may not be possible: because of cost, because the intervention is taking place everywhere (thereby leaving no suitable control areas), or because suitable baseline surveys were not undertaken before the intervention started. In these cases, a weaker version of the indicator can sometimes be computed, for example simply by comparing the proportions of children living in homes relying on coal, wood or dung as the main fuel source for cooking and heating before and after intervention in the one area; or by comparing these proportions between intervention and control areas only at one moment in time, after intervention. Inevitably, however, the indicator is more difficult to interpret in these situations, because it becomes impossible to adjust for confounding by other factors, and thus to assess the amount of change actually attributable to the intervention. Many other variations on this indicator are possible, to reflect local circumstances. Different fuel sources or different heating and cooking facilities might be selected, for example, as a basis for the indicator (e.g. 'open fires or unvented gas cookers and heaters' may be more appropriate in more developed areas of the world). Similar indicators can also be designed to include other sources of indoor air pollution, such as asbestos-containing materials, radon-bearing rocks or cements, or homes in which adults smoke.
Examples	None known
Useful references	Albalak, R., Frisancho, A.R. and Keeler, G.J. 1999 Domestic biomass fuel combustion and chronic bronchitis in two rural Bolivian villages. *Thorax* 54,

	1004-8. Bruce, N., Perez-Padilla, R. and Albalak, R. 2000 Indoor air pollution in developing countries: a major environmental and public health challenge. *Bulletin of the World Health Organization* 78, 1078-92. Sharma, S., Sethi, G.R., Rohtagi, A., Chaudhary, A., Shankar, R., Bapna, J.S., Joshi, V. and Sapir, D.G. 1998 Indoor air quality and acute lower respiratory infection in Indian urban slums. *Environmental Health Perspectives* 106, 291-7. Smith. K.R. 1987 *Biomass fuels, air pollution and health. A global review.* New York: Plenum Press. WHO 1999 *Environmental health indicators: framework and methodologies.* Geneva: WHO. (Available at http://www.who.int/docstore/peh/archives/EHIndicators.pdf)