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Summary Measures of Socioeconomic Inequalities in Health

TECHNICAL REPORT
September 2013

Public Health Ontario

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How to cite this document:
Ontario Agency for Health Protection and Promotion (Public Health Ontario). Summary measures of socioeconomic inequalities in health. Toronto, ON: Queen's Printer for Ontario; 2013.

ISBN 978-1-4606-2945-1 [PDF]

Public Health Ontario acknowledges the financial support of the Ontario Government.

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Part of this work was conducted in completion of a practicum for the MPH epidemiology program at the University of Toronto, Dalla Lana School of Public Health

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Contents

List of Abbreviations

ABSM	Area Based Socioeconomic Measure
AD	Absolute Difference
CCHS	Canadian Community Health Survey
CI	Confidence Interval
CIHI	Canadian Institute for Health Information
DA	Dissemination Area
DRR	Disparity Rate Ratio
HCI	Health Concentration Index
INSPQ	Institut National de Santé Publique de Québec
MOHLTC	Ministry of Health and Long-Term Care
ON-Marg	Ontario Marginalization Index
OPHS	Ontario Public Health Standards
PAF	Population Attributable Fraction
PHAC	Public Health Agency of Canada
PHU	Public Health Unit
QAIPPE	Quintile of Adjusted Income per Person Equivalent
RII	Relative Index of Inequality
ScotPHO	Scotland Public Health Observatory
SES	Socioeconomic Status
SII	Slope Index of Inequality
UK	United Kingdom
WHO	World Health Organization

Glossary of Terms

Absolute Measures of Inequality: A simple arithmetic differences between a group rate and a specified reference point.[1] Absolute measures of inequality presented in this report are the absolute difference and the slope index of inequality.

Area Based Socioeconomic Measures: A number of tools that use information to characterize the socioeconomic profile of a geographic area rather than individuals.[2] Area based socioeconomic measures described in this report include the quintile of adjusted income per person equivalent, the Ontario Marginalization Index, and the Institut National de Santé Publique de Québec index of material and social deprivation.

The Health Concentration Index: A summary measure of inequality which is measured as two times the area between the concentration curve (i.e., the curve modelling the cumulative share of the health outcome in the population against the cumulative share of the population, ranked by SES from lowest to highest) and the line of equality (i.e., the 45 degree line where the cumulative percent of the population equals the cumulative share of the health outcome).[3]

Health Inequality: Any difference in the distribution of health status or health determinant between different population groups.[4]

Health Inequity: A difference in the distribution of health status or health determinants between different population groups which are unnecessary, avoidable, unjust and unfair.[4]

Measures of Socioeconomic Status: Measures used to divide a population by socioeconomic status. These measures can be individual measures of socioeconomic status, like household income quintile, or area based measures of socioeconomic status, like average neighbourhood income quintile.[2]

Measures of Total Population Impact: Measures of inequality which take into account not only the effect of decreasing socioeconomic status on health but also the extent of socioeconomic inequalities within the population. The larger the extent of inequalities by SES the higher these measures of total impact will be.[5] Measures of total population impact described in this report are the population attributable fraction, the slope index of inequality, the relative index of inequality and the health concentration index.

Modifiable Aerial Unit Problem: A bias which occurs when geographies used to estimate area level socioeconomic status are determined based on convenient administrative factors rather than meaningful geographic units with similar socioeconomic profiles.[2]

Ontario Marginalization Index: A complex area based socioeconomic measure which takes into account multiple dimensions of marginalization including: material deprivation, residential instability, dependency, and ethnic concentration, and is based on data from the Canadian Census.[6]

QAIPPE: A simple area based socioeconomic measure of neighbourhood income per person equivalent, adjusted for household size, which is released by Statistics Canada.[7]

Population Attributable Fraction: A summary measure of inequality, measured as the projected reduction in the rate of a health indicator if each socioeconomic group experienced the rate of the most advantaged group, expressed as a fraction of the total health outcome.[8]

Priority Populations: The Ontario Public Health Standards defines priority populations as those populations that are at risk and for whom public health interventions may be reasonably considered to have a substantial impact at the population level.[9] An alternative definition proposed by Sudbury & District Health Unit states that priority populations are groups at increased risk of socially produced health inequities.[10]

The Range: A summary measure of inequality which compares the rate of a health variable between the most and least advantaged groups. The range can either be an absolute measure of inequality, known as the absolute difference (AD), which takes the difference in rates of the health outcome between the highest and lowest socioeconomic groups, or a relative measure of inequality, known as the disparity rate ratio (DRR) which divides the rate of the least advantaged group by the rate of the most advantaged group.[8]

The Relative Index of Inequality: A relative summary measure of inequality. There are two forms of the relative index of inequality (RII), the RII_{mean} and the RII_{ratio}. The RII_{mean} is calculated by dividing the slope index of inequality by the mean rate of the health outcome in the population.[11] The RII_{ratio} represents the predicted value of the health outcome in the least advantaged divided by the predicted value of the most advantaged.[12]

Relative Measures of Inequality: Measures which express the difference between rates in terms of a specified reference point.[1] Relative measures of inequality described in this report are the disparity rate ratio, the population attributable fraction, the relative index of inequality, and the health concentration index.

The Slope Index of Inequality: An absolute summary measure of inequality, which represents the slope of the regression comparing the mean health outcome in a socioeconomic group to the cumulative percent of the population, ranked by socioeconomic position (from lowest to highest).[13]

Socioeconomic Status: This report defined socioeconomic status by individual factors relating to social position or economic situation such as income, occupation level, and educational attainment, or area level factors such as average neighbourhood income and neighbourhood deprivation indexes.

Summary Measures of Inequality: Measures which quantify the degree of health inequalities by relating measures of socioeconomic status to health outcomes.[5]

Main Messages

Measuring inequalities in health is a first step in determining health inequities. Once a population is determined to have an unequal distribution of health, the causes and context should be examined to determine whether these differences are inequitable and socially produced. This method can help in the identification of priority populations (i.e., at-risk populations for whom public health interventions may be reasonably considered to have a substantial impact at the population level).

This report describes methods of measuring inequalities in health by socioeconomic status for a technical audience. Recognizing the importance of addressing inequalities in health, this report describes the published approaches of quantifying inequalities that could be used on the provincial level in Ontario and by public health units to measure health inequalities and inform priority setting.

The results highlight five summary measures of inequality which have a strong basis in the scientific literature. Choice of measure will depend on the purpose or research question, informed by the advantages and limitations identified in this report. Often the choice of summary measure is not explicit and more than one measure should be provided in order to describe different aspects of inequality.

This report provides the necessary scientific and technical basis of measuring inequalities and will help public health units to identify and target programs to priority populations. Future work could address the applications of measuring health inequalities to defining inequitable distributions of health and identifying priority populations in clear language for public health decision-makers.

Executive Summary

BACKGROUND

Despite improvements in health status of the population, the gap in health between the most and least advantaged in society has been growing.[14,15] Considerable evidence suggests a socioeconomic gradient of health whereby ill health outcomes are concentrated in more socioeconomically deprived groups.[14,16] In Ontario, in recent years, emphasis has been placed on reducing socioeconomic inequalities in health. The Ontario Public Health Standards (OPHS)[9] require that public health units (PHUs) provide information on health inequities, as well as use this information to assess population needs. Health inequities refer to differences in health status between population groups which are unjust, while health inequalities refer to any differences in health status and can be measured quantitatively.[17] To accomplish the goals set out in the OPHS, it is important to first quantify inequalities at the PHU level.

This report explores and critically appraises methods of measuring health inequalities by socioeconomic status (SES) on the provincial and PHU level in Ontario. This includes methods of measuring SES through individual and area based measures and calculating summary measures of inequality, relating SES to health outcomes.

APPROACHES AND LIMITATIONS

A literature review was performed to identify suitable summary measures of inequality, focusing on methods of calculation, critical appraisals and practical applications. Summary measures were selected to reflect those commonly used in the literature, particularly within a Canadian context, and with a strong research base.

Using smoking as an example, an analysis of smoking inequalities was performed to illustrate the use of these summary measures in measuring inequalities. Data from the 2009–10 cycle of the Canadian Community Health Survey (CCHS) were linked with two area-based measures of socioeconomic status, a simple measure known as neighbourhood income quintile (QAIPPE) and a more complex measure known as the Ontario Marginalization Index (ON-Marg). The ON-Marg dimensions of material deprivation and residential instability were considered. Rates of smoking were calculated for each quintile as defined by these area-based measures, as well as by quintile of individual level household income. Summary measures relating socioeconomic status to health outcome were then calculated.

Summary measures of inequality identified were limited to available and commonly used measures. This report provides summary measures that are supported in the scientific and grey literature but does not provide an exhaustive list of available measures.

RESULTS

Five summary measures were shown in the literature to effectively measure health inequalities:

1) range
2) population attributable fraction
3) slope index of inequality
4) relative index of inequality
5) health concentration index

The various summary measures differed in their complexity of calculation and in their consideration of different population segments. The range and population attributable fraction were defined as simpler measures of inequality, which were faster to calculate but which ignore certain information on the study population and its relationship with the health outcome. The slope and relative index of inequality as well as the health concentration index were shown to be more complex measures which require the use of sophisticated statistical software and which provide a more complete description of the study population. The health concentration index provides a good visual description of inequalities, while the population attributable fraction can be used to describe the population burden of illness.

An analysis of inequalities in smoking between socioeconomic groups found consistent results across all summary measures, though more complex measures were less likely to find statistically significant inequalities at the PHU level when using survey data with smaller sample sizes such as the CCHS. Statistically significant inequalities were found for smoking for all summary measures at the provincial level for Ontario. Area-based measures of SES gave higher values for inequalities as compared to the individual level measure of household income.

CONCLUSIONS

This report demonstrates that each summary measure of inequality has its merits. Choice of measure should depend on different factors including the purpose or research question and the data available. Comparing results from several summary measures is useful in understanding the different dimensions of inequality in a population. Less complex methods of calculating inequalities such as the range and population attributable fraction can provide useful results at the PHU level, particularly when rapid decisions are necessary. More complex methods such as the slope and relative index of inequality and the health concentration index provide a more rigorous method for measuring inequalities and can complement results found using simpler measures.

Introduction

The Ontario Public Health Standards (OPHS), released by the Ministry of Health and Long-Term Care (MOHLTC), demonstrate a commitment to reducing health inequities. These standards state that "addressing determinants of health and reducing health inequities are fundamental to the work of public health in Ontario." Requirements of the board of health under the Foundational Standard include using information on inequities to assess the needs of the population, tailor programs and services for priority populations, and provide population health information on health inequities.[9] Health inequities refer to differences in health status between population groups which are unjust, while health inequalities refer to any differences in health status and can be measured quantitatively.[17] To accomplish this mandate, it is important that inequalities are first quantified. This report examines methods of measuring socioeconomic status (SES) and the summary measures of inequality relating SES to health outcomes.

The objectives of this report are to:

1) Identify measures of SES and summary measures for quantifying health inequalities.
2) Use information in the literature and from an analysis of inequalities in Ontario to provide a detailed profile of the existing summary measures of inequality and offer technical advice to public health epidemiologists.
3) Compare results of identified summary measures using individual and area based measures of SES.

One major advantage of computing summary measures of inequality is the ability to compare inequalities over time, geographic areas, and across various health indicators.[1] While the report will largely focus on measuring socioeconomic inequalities, some of the methods used can be adapted to measure other types of inequalities, for example, inequalities between ethnic groups.

This report begins with background information on health inequalities, followed by a review of individual and area-based measures of SES. It then describes the methods used to identify measures of inequality. Several summary measures of inequality will be discussed, including their major applications, strengths and limitations. Scenarios that favour the use of one summary inequality measure over another are considered, and methods for calculating these summary measures at the provincial and public health unit (PHU) level in Ontario are presented. Following this, an analysis examining inequality of smoking rates by SES in Ontario and four selected PHUs of various sizes and geographies is presented to illustrate the use of the different summary measures of inequality.

This report includes the following:

- background information on health inequalities
- a review of individual and area based measures of SES
- the methods used in this report to identify measures of inequality
- a discussion of several summary measures of inequality including their major applications, strengths and limitations and methods of calculation
- an illustrative analysis examining inequality by smoking rates by SES in Ontario and four selected PHUs of various sizes and geographies
- a discussion including technical advice on use of summary measures

Inequities vs. Inequalities

Inequality and inequity are two different concepts. The World Health Organization (WHO) defines a health inequality as any difference in the distribution of health status or health determinants between different population groups. Health inequalities can be attributed to free choice, biological variations, the physical environment, and factors beyond the control of the individuals concerned. For example, differences in physical capabilities between elderly and younger people in the population would be considered an inequality. In contrast, inequity is an ethical concept which reflects principles of social justice.[17] Health inequities are defined as inequalities in which the outcome is unnecessary and avoidable as well as unjust and unfair. For example, differences in health care accessibility between socio-economic groups may be interpreted as an inequality as well as an inequity, while some differences in physical capabilities between elderly and younger people would not be considered an inequity as it is unavoidable.[4] In general, differences due to biological variations, fully informed decisions to participate in higher risk behaviours, and chance are not considered inequities.[18,19] Many would describe health inequalities across socioeconomic groups as unjust because they often reflect an unfair distribution of the social determinants of health.[19,20]

Health inequalities can be measured quantitatively while health inequities cannot. This is because identifying health inequities requires the use of judgment regarding the social justice of an inequality, which may depend on the causes of the inequality and the context of the local community.[5] Better understanding of the causes and context of health inequalities can also help PHUs to better target interventions and advocate for necessary changes. This report will focus on quantitative measures of health inequalities. Identifying inequalities is a first and important step in the identification of inequities.

Socioeconomic Inequalities in Health

Considerable evidence indicates the existence of inequalities in the burden of disease between groups of differing SES.[11,14,16,21,22] The *Black Report,* published in the United Kingdom (UK) in 1980, brought attention to inequalities in health by social class. The study, conducted by the UK department of Health and Social Security, demonstrated significantly higher mortality rates among those in the lowest social class compared to the highest. Despite showing overall improvements in health over time, the report demonstrated that inequalities in health by SES had been increasing since World War II.[11,15] Around the world, a similar increased rate of poor health outcomes among those of low socioeconomic position has been demonstrated, with adverse health outcomes concentrated in the most deprived populations.[14] Many of these studies have demonstrated a socioeconomic gradient in which decreases in SES are associated with incremental increases in health outcomes. In Canada, socioeconomic factors which have been seen to influence health include: income, employment, education, food security, and social supports and connectedness.[23] Health variables which have demonstrated inequalities by SES include high risk health behaviours, such as smoking and alcohol use, access to health care services, and various health outcomes.[24] Examples of health outcomes shown to vary by SES include chronic diseases, injuries, self-rated health, oral health, and mortality.[5,25-32]

Although those living below a certain poverty threshold (absolute poverty) demonstrate inequalities due to lack of adequate food/shelter —a clear gradient in SES has been shown, indicating that health outcomes are also affected by factors beyond absolute poverty. The relative income hypothesis states that health status depends not only on individual SES but also on complex factors beyond absolute poverty, including the individual's socioeconomic position within society.[19]

Measures of Socioeconomic Status

Measuring health inequalities by SES involves dividing a population into appropriate socioeconomic groups; these groups can be individual measures of SES or area based.[33] In measuring health inequalities, populations are often divided into quintiles of SES.[21,34-37] Summary measures of inequality determine the degree to which these socioeconomic groups are related to health outcomes. Therefore, before looking at summary measures it is important to examine the different methods of dividing a population into socioeconomic groups.

INDIVIDUAL MEASURES OF SOCIOECONOMIC STATUS

Individual measures of socioeconomic status use individual level information such as income, educational attainment, or occupation to classify populations into socioeconomic groups (e.g., income quintiles, high school to university or occupational "levels").[24] Individual level information is the most direct way of classifying individuals by socioeconomic information and is generally considered the standard measure of SES. However, individual level information is often unavailable from major public health databases and individual level SES data from self-reported surveys are often incomplete.[2,38] When

measuring health inequalities, income is often chosen as a measure of individual SES as it is generally considered the SES measure with the greatest impact on health inequalities.[39] However, other individual measure of SES (i.e., educational attainment and occupational level) can be used effectively to divide a population into socioeconomic groups in order to measure socioeconomic inequalities.

AREA-BASED SOCIOECONOMIC MEASURES

Area-based socioeconomic measures (ABSMs) encompass a number of tools that use information to characterize the socioeconomic profile of a geographic area rather than individuals. ABSMs can be very simple measures of SES such as average neighbourhood income (i.e., the quintile of adjusted income per person equivalent), or very complex, such as a multicomponent deprivation scores like the Ontario Marginalization Index (ON-Marg).[2,6] In recent years, usage of ABSMs for measuring SES has been increasing. Reasons for using ABSMs include growing interest in place and context as a determinant of health, and the need to incorporate socioeconomic inequality data when informing place-based decision making.[2] ABSMs have been recognized as independent predictors of health due to the importance of contextual or area level influences on health.[38,40] Commonly used databases such as vital statistics and health administration data rarely provide information on socioeconomic factors. When individual level data on SES is absent, ABSMs can be used as a proxy for individual level information.[33] This involves matching individuals to a spatial location using information on place of residence such as postal codes.[2]

In Canada, many ABSMs are provided at the level of dissemination areas (DAs).[2,6] DAs are defined as small, relatively stable geographic units and are the smallest standard geographic area for which all census data is disseminated and cover all of Canada. The average population of a DA is about 700 people.[41] As DAs are the smallest geographic area for which census data are disseminated, they are recommended when using area-based measures as a proxy for individual SES to give the most accurate results.

The choice of using an area-based measure will depend on factors such as the data and resources available, and the purpose or research question. Before choosing to use an ABSM, the strengths and limitations of ABSMs as compared to individual measures of SES should be well understood. One major advantage of using an ABSM is that area-based measures are frequently consistent with individual level indicators (the direction of the relationship is similar), as well as being statistically reliable.[29] ABSMs also characterize the entire population, and allow inequalities to be tracked through time and by geographic location.[24,29] Importantly, ABSMs can both measure contextual factors of SES, (for example, social influences and access to resources) and account for aspects of individual level SES. One benefit of measuring SES by area is the possibility of mapping inequalities, which can then be used to provide information and context to local decision-makers.[2,36,38,42]

A potential bias in the use of ABSMs can occur when geographies used to estimate area level SES are determined based on convenient administrative factors rather than meaningful geographic units with similar socioeconomic profiles. This bias is technically known as the modifiable aerial unit problem.[2] There are several disadvantages of using ABSMs as proxies for individual level data. ABSMs can underestimate the effects found using individual level data due to a non-differential misclassification

bias. For example, those living in a highly deprived area are not necessarily of low SES (or vice versa). Alternatively, ABSMs can also overestimate an effect size if there is a contextual effect of area level deprivation, independent of individual level deprivation.[33,43] For example, higher rates of smoking in a low income neighbourhood could create social pressures which influence an individual's risk of smoking in addition to individual level factors relating low income and risk of smoking.[44]

Because of substantial limitations in using area-based measures as proxies for individual measures, ABSMs should not be used to make inferences about individual level deprivation when individual level SES data is available.[33] To account for contextual factors of socioeconomic deprivation, a multilevel model which incorporates individual and area level measures may be useful.[36,38] The choice to use ABSMs depends on the context and purpose of the analysis. If one wants to measure health inequalities by area to identify areas at increased risk of poor health outcomes, or if one wishes to display inequalities on a map to better understand regional inequalities, then the use of ABSMs may be preferable to individual level data.[2] However, when using ABSMs as a primary predictor of health it is important to interpret results accordingly, (i.e., as an effect of living in a deprived area rather than an effect of individual socioeconomic position).[43]

Tables 1-A: Advantages and Limitations of Using ABSMs as a Measure of SES

Advantages	Limitations
• Less missing information compared to individual SES variables • Takes into account contextual role of SES	• Census boundaries don't necessarily apply to "real" neighbourhoods with homogeneous populations (modifiable aerial unit problem)

Tables 1-B: Advantages and Limitations of Using ABSMs as a Proxy for Individual Data

Advantages	Limitations
• Often available when individual level data on SES is absent	• Neighbourhood characteristics don't always reflect individual characteristics (i.e., ecologic fallacy) • Contextual factors influence effect size

This report presents three widely used ABSMs: the quintile of adjusted income per person equivalent (QAIPPE), the Ontario Marginalization Index (ON-Marg) and the index of material and social deprivation created by the Institute National de Santé Publique de Québec (INSPQ).

Quintile of Adjusted Income per Person Equivalent (QAIPPE)

The quintile of adjusted income per person equivalent (QAIPPE) is a simple ABSM which is released by Statistics Canada. The QAIPPE is a measure of neighbourhood income per person equivalent, adjusted for household size, and is based on census summary data at the DA level. The single person equivalents used to adjust household income are 1.00 for 1 person living in a household, 1.25 for 2 persons, 1.55 for 3 persons, 1.95 for 4 or 5 persons, and 2.44 for 6 or more persons sharing the same household. To create the QAIPPE, Statistics Canada first used the DA average neighbourhood income per person equivalent to rank all DAs and then divided the DAs into fifths, with the first quintile representing the lowest SES and the fifth quintile representing the highest SES DA.[7]

Ontario Marginalization Index (ON-Marg)

Another, more complex ABSM is the Ontario Marginalization Index (ON-Marg) which looks at different dimensions of marginalization, accounting for multiple contributing factors. The ON-Marg was specifically developed to examine inequalities in health by population groups or geographic areas in Ontario. Like the QAIPPE, the ON-Marg can be calculated at the DA level and is based on Canadian census data. Unlike the QAIPPE, that considers material inequality alone, the ON-Marg examines additional dimensions of inequality. There are four dimensions to the ON-Marg: material deprivation, residential instability, dependency, and ethnic concentration. To calculate the ON-Marg, all DAs are assigned a score for each dimension of marginalization and ranked from lowest to highest. The DAs are then divided into quintiles for each dimension, creating four separate rankings of inequality.[6]

The index of material deprivation is based on the following area-based factors:

- the proportion of the population above the age of 25 without a certificate, diploma, or degree
- the proportion of lone parent families
- the proportion of government transfer payments
- the proportion of those unemployed above the age of 15
- the proportion below the low income cut-off
- the proportion of homes needing major repair

The index of residential instability is based on:

- the proportion of the population living alone
- the proportion of youth aged 5-15
- the average number of persons per dwelling
- the proportion of multi-unit housing
- the proportion of population married or common low
- the proportion of dwellings owned

- the proportion of residential mobility

The dependency dimension is based on:

- the proportion of seniors
- the dependency ratio (population 0 to 14 and 65+ / population 15 to 64)
- the labour force participation rate (age 15 and older)

Ethnic concentration is based on:

- the proportion of five year recent immigrants
- the proportion of visible minorities

Institut National de Santé Publique de Québec (INSPQ) index of material and social deprivation

Another, complex ABSM is the index of material and social deprivation created by the INSPQ, hereby referred to as the INSPQ index. The INSPQ index is calculated at the DA level and is drawn from Canadian census data for 1991, 1996, 2001, and 2006. Like the ON-Marg, the INSPQ index examines material and social dimensions of inequality. There are two dimensions to the INSPQ index: material deprivation, and social deprivation. To calculate the INSQP index, all DAs are assigned a score for each dimension of deprivation and ranked from lowest to highest. The DAs are then divided into quintiles for each dimension, creating two separate rankings of inequality.[45]

The index of material deprivation is based on the following area-based factors:

- The proportion of the population aged 15 years and over without a high school diploma or equivalent
- The employment to population ratio for the population 15 years and over
- The average income of the population aged 15 years and over

The index of social deprivation is based on the following area-based factors:

- The proportion of the population aged 15 and over living alone;
- The proportion of the population aged 15 and over who are separated, divorced or widowed;
- The proportion of single-parent families

Methods

A review of the scientific and grey literature was performed to identify appropriate summary measures of inequality including methods of calculation, interpretation, and advantages and limitations. Grey literature sources included government and non-government reports from the Public Health Agency of Canada (PHAC), the Canadian Institute for Health Information (CIHI), Scotland Public Health Observatory (ScotPHO), the World Bank, and the U.S. Department of Health and Human Services.

A systematic search strategy was undertaken for the literature review. A snowball strategy was used to identify articles related to measures and indicators of health equality. To complement this search strategy, English language articles which explored the concepts of health equity or health equality as well as indicators or statistical measures were searched in MEDLINE. A detailed search strategy, including all the search terms, can be found in Appendix A. References were reviewed to identify additional articles relevant to measuring socioeconomic inequalities.

Review documents focusing on measurement of socioeconomic inequalities were used to inform the selection of summary measures of inequality. In addition, measures used in Canada for quantifying health inequalities by SES were considered for inclusion.

To ensure that the summary measures could be applied to measuring inequalities at the provincial level in Ontario and at the PHU level, an analysis was carried out of inequalities in Ontario and four selected PHUs of various sizes and geographies, using smoking as an example.

Results

Selecting Summary Measures of Inequality

The decision to use a specific summary measure of inequality often depends on the purpose or research question, and the data and resources available.[46] These summary measures can either be absolute measures of inequality, arithmetic differences between a group rate and a specified reference group, or relative measures of inequality, which are expressed as a percentage difference between a group rate and a specified reference point.[1]

Wagstaff et al.[3] present guidelines for selecting summary measures of inequality. These guidelines state that summary measures must:

a) reflect the socioeconomic dimension of inequalities in health

b) reflect the experiences of the entire population

c) be sensitive to changes in the distribution of the population across socioeconomic groups

Based on these guidelines, only three measures of inequality were identified:

1) slope index of inequality

2) relative index of inequality

3) health concentration index

Notably, these three measures involve complex analyses and are related to one another mathematically through a simple equation.[3] However, Mackenbach and Kunst[5] have argued that the guidelines presented by Wagstaff et al. are overly strict and ignore measures which could provide insight into the nature of inequalities while being easier to calculate with more straightforward interpretations. Additional measures which have been used to calculate inequality in Canada are the range, as well as the population attributable fraction (PAF).[8] The next section will explore the summary measure of inequality identified in the literature: the range, the PAF, the slope and relative index of inequality, and the health concentration index.

Relating SES to Health Outcome: Summary Measures of Inequality

THE RANGE

The range is a measure of inequality which compares the rate of a health variable between the most advantaged group and the least advantaged group. The range can be an absolute measure of inequality, known as the absolute difference (AD) or absolute range, which takes the difference in rates of the health outcome between the highest and lowest socioeconomic groups. By convention, the most affluent group is used as the referent category.[8] When the AD is equal to zero, equality in health is said to exist. A 95% confidence interval (CI) which does not include zero indicates the presence of significant inequalities in health.

The range can also be a relative measure of inequality, known as the disparity rate ratio (DRR) or the relative range. The DRR is a measure of a socioeconomic gap, dividing the rate of the least advantaged group by the rate of the most advantaged group. A DRR of one represents the absence of inequality in the population. For an adverse health event, a DRR greater than one represents an increase in ill health amongst the least advantaged.[5,8] A 95% CI which does not include one indicates the presence of significant inequalities in health. The DRR can be interpreted as the relative disparity between the highest socioeconomic group and the lowest.

Calculating the Range and 95% CIs

The absolute difference can be calculated using the formula:

$$AD = R_i - R_r$$

Where R_i refers to the rate of the health outcome in the least advantaged group and R_r represents the rate of the health outcome in the most advantaged (or reference) group.

A method for calculating 95% CIs of the range is found in Cheng, et al.[48] which also provides a SAS macro for computing the range measures and 95% CIs. Calculation of the 95% CI for the AD includes computing the standard error using the following formula:

$$SE_{diff} = \sqrt{SE_i^2 + SE_r^2}$$

Where SE_i represents the standard error of the prevalence of the health outcome in the non-reference group and SE_r represents the standard error of the prevalence in the reference group (or the most advantaged group).

The disparity rate ratio can be calculated using the formula[8]:

$$DRR = \frac{R_i}{R_r}$$

The standard error for the DRR is calculated through the equation:

$$SE_{DRR} = \sqrt{RSE_{diff}^2 + RSE_r^2}$$

where RSE_{diff} is the relative standard error of the difference, computed by the formula:

$$RSE_{diff} = \sqrt{\frac{SE_i^2 + SE_r^2}{R_i - R_r}}$$

Where R_i and R_r are the prevalence rates in the non-reference and reference populations respectively.

The RSE_r is the relative standard error of the reference group and can be computed using the equation:

$$RSE_r = \frac{SE_r}{R_r}$$

The 95% CI is then calculated for both the AD and the DRR using the equation:

$$T \pm 1.96\, SE_T$$

Where T is the point estimate of the range measure.

This approach assumes that the range measures themselves are normally distributed with a certain mean and standard deviation

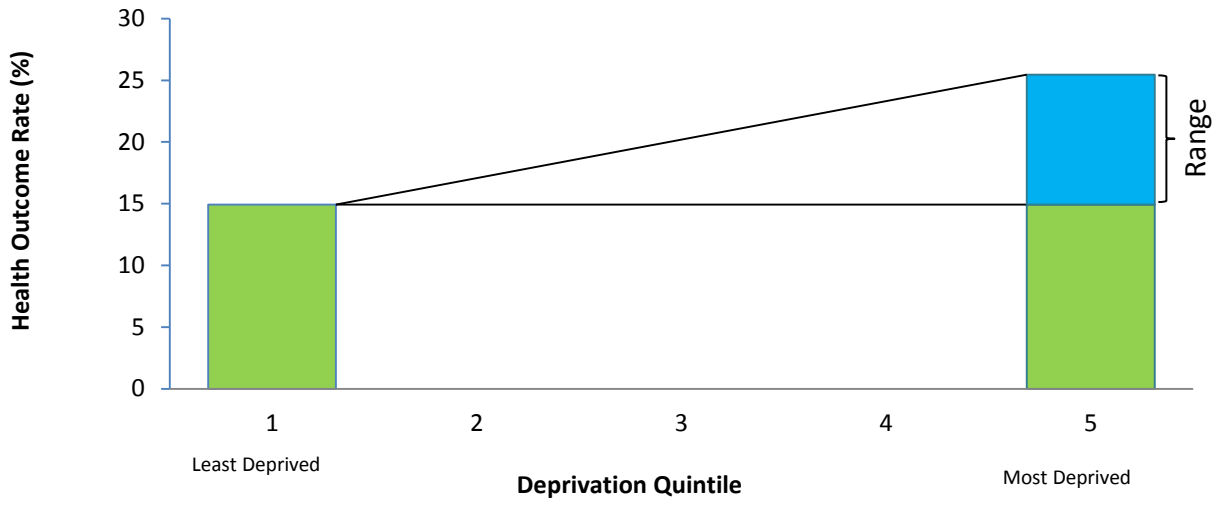
Interpreting the Range

Large values of the AD indicate high levels of inequality. Significance is determined if 95% CIs do not include 0.

Large values of the DRR indicate high levels of inequality. Significance is determined if 95% CIs do not include 1.

There are certain advantages to using the range as a measure of inequality. Calculation of the range is easy to perform and the interpretation is straightforward. Figure 1 illustrates the range. The measures are similar to a relative rate and relative difference, metrics commonly used in the health science literature, and are therefore familiar to public health practitioners. The measure also provides flexibility in the groups being compared.[5] The range can be adapted as a relative rate comparing any two socioeconomic groups. This is particularly useful when the socioeconomic variable does not reflect an ordinal measure of SES with a clear hierarchical structure, such as income. For example, in many studies conducted in England and Wales, population health is compared according to nominal measures, such as occupation, a factor which is more difficult to translate into an ordinal socioeconomic variable.[11,22] By adapting the range, it would be possible to compare rates in health status between different occupational groups without making assumptions about the hierarchical structure. Additionally, this measure can be adapted to studying inequalities in health that cannot be ranked by SES, for example, comparisons between ethnic groups.[47]

Figure 1: Visual Depiction of the Range Measure



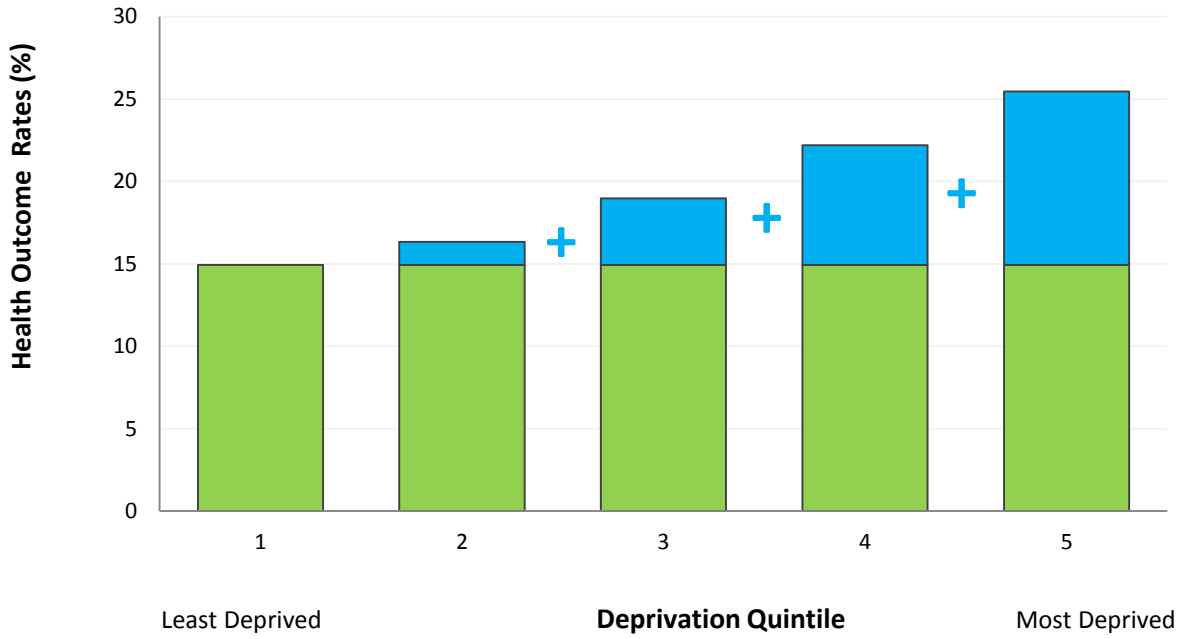
The range provides a measure of effect of low SES but does not present a measure of total population impact. When calculating the range, there is no consideration given to what proportion of the population fits into each socioeconomic category. This factor makes it difficult to use the range when comparing inequalities across regions and time, as the distribution of populations between socioeconomic groups may differ.[3] The range also ignores the health status of the in-between socioeconomic groups. As a result, the measure does not represent inequalities well when there is no clear linear gradient between the most and least advantaged groups.[46]

Applications where the range would be most useful include instances where there is no clear hierarchical structure between socio-economic groups,[47] in situations where rapid decisions are needed, and in preliminary measures of inequality to generate interest for further invesitigation.[5]

POPULATION ATTRIBUTABLE FRACTION

As applied to health inequalities, the population attributable fraction (PAF), also known as the potential rate reduction, is the projected reduction in the rate of a health indicator if each socioeconomic group experienced the rate of the most advantaged group. The measure is based on the concept of preventable morbidity and mortality in which the health status of the most advantaged group is achievable by the whole population. The PAF is calculated by summing the potential reduction in rates for each of the socioeconomic groups, accounting for the effect size of lower SES and the proportion of the population in each group. If PAF is significantly different from zero then an inequality is said to exist; a higher PAF is associated with greater inequalities.[5,8] Figure 2 illustrates the PAF. The absolute number of an outcome or risk factor in a population related to socioeconomic inequalities can be determined by multiplying the PAF by the total number of those with the outcome or risk factor in the population.

Figure 2: Visual Depiction of PAF



Calculating the PAF:

$$PAF = \frac{\sum_{i=1}^{5} P_i(\frac{R_1}{R_5} - 1)}{1 + \sum_{i=1}^{5} P_i(\frac{R_1}{R_5} - 1)}$$

Where R_i is the rate of health outcome in the non-reference group, R_5 is the rate of the health outcome in the reference group (assuming five quintile), and P_i is the proportion of the population in the socioeconomic group.[8]

Interpreting the PAF

Large values of the PAF indicate high levels of inequality. Significance is determined if 95% CIs do not include 0.

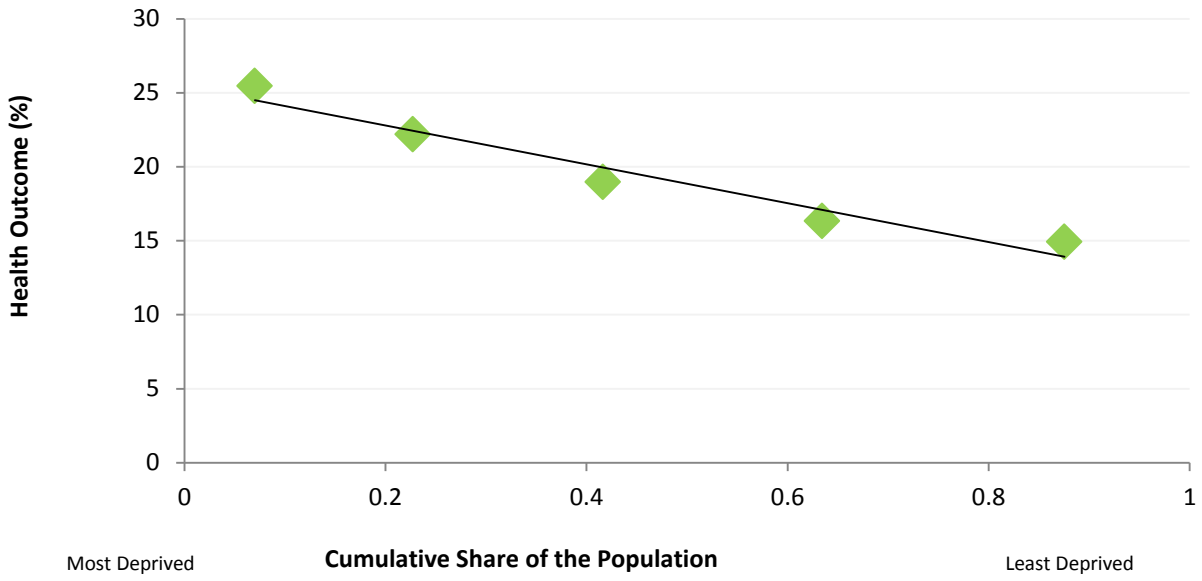
Unlike the range, the PAF is a measure of total population impact. Measures of total population impact, as identified by Mackenback and Kunst[5] are measures in which the extent of socioeconomic inequalities within a population are considered. This factor is reflected in the third guideline for summary measures of inequality described by Wagstaff et al., [3] "that the measure be sensitive to changes in the distribution of the population across socioeconomic groups." The PAF also considers all socioeconomic groups, not just the extremes. The PAF shares some advantages with the range: it is quick to calculate with a straightforward interpretation, and it is commonly used in the health science literature and therefore is familiar to public health practitioners.[5] Lastly, its ability to demonstrate the population burden of disease attributable to SES makes it very relevant from a decision maker's perspective.[46] An important disadvantage of using the PAF is that it ignores information on the association between SES and the frequency of the health outcome. For example, the PAF value could be similar for a systematic linear increase in a health outcome with decreasing SES and a non-systematic association between SES and health.[5] For this reason, the PAF does not measure inequality well when there is no clear gradient in health status between the highest and the lowest socioeconomic groups.[46]

The PAF would be most useful in matters where rapid decisions are needed or to provide preliminary measures of inequality that may generate interest for further invesitigation.[5]

SLOPE AND RELATIVE INDEX OF INEQUALITY

The slope and relative index of inequality are regression based methods for determining the degree of inequality in a population. The slope index of inequality (SII) is considered an absolute measure of inequality, and represents the slope of the regression comparing the mean health outcome in a socioeconomic group to the cumulative percent of the population, ranked by socioeconomic position (from lowest to highest). The independent variable for the regression line, known as the relative rank, is calculated by arranging the groups in order from lowest to highest SES and assigning the cumulative proportion of the population to each group. The midpoint of the population proportion for the most deprived socioeconomic group is taken as its relative rank. For each consecutive group the relative rank is calculated by adding the midpoint of its population proportion to the proportion of the previous groups. For grouped data, use of an ordinary least squares regression would result in heteroskedacity of the error term (i.e., when different groups' errors have different variances), which violates the assumption of linear regression.[13] Therefore, the regression most commonly used is a weighted least squares regression, where the weights are proportional to the population size of the socioeconomic groups.[11] Figure 3 provides a visual illustration of the SII.

Figure 3: Visual Depiction of SII



Calculating the Slope and Relative Index of Inequality

The SII and RII transformed regression equation is given by the formula:

$$Y * \sqrt{a} = 0 + \sqrt{a} + b * \sqrt{a}$$

where $\sqrt{a}$ is the square root of the population proportion in each socioeconomic group, Y is the health outcome variable and *b* is the relative rank variable.[64]

The SII is interpreted as the absolute difference between the most and least deprived; it is significant if the 95% CI does not include zero. If the SII is negative, then the health outcome is said to be greater in those of lower SES.[46] The interpretation is similar to a relative difference, but the intermediate socioeconomic groups are accounted for as well the size of the socioeconomic groups in the calculation of the slope coefficient of the regression. The SII is sensitive to the mean rate of health in the population. For example, if the mean rate of ill health in the population doubled, the SII would double as well.[1,11]

Another related measure of inequality, known as the relative index of inequality (RII), is not sensitive to the mean rate of health in the population. There are two forms of the RII, the RII_{mean} and the RII_{ratio}. The RII_{mean} is calculated by dividing the SII by the mean rate of the health outcome in the population. The

interpretation is the proportionate decline in the health outcome over the population, ranked by SES. A large score of the RII_{mean} indicates the presence of inequalities. A negative RII_{mean} indicates that the health outcome is greater in those of lower SES. Significance is determined if the 95% CI does not include zero.[11] The RII_{ratio} represents the predicted value of the health outcome in the least advantaged divided by the predicted value of the most advantaged. A large score of the RII_{ratio} indicates high levels of inequality, significance is determined if the 95% CI does not include one.[12] Though similar to a relative rate, the regression based measure is able to account for the intermediate socioeconomic groups as well as the distribution of the population between socioeconomic groups.[1] The RII_{ratio}, as compared to the RII_{mean}, tends to overestimate differences.[48]

Interpreting the SII/RII

Large negative values of the SII indicate high levels of inequality with higher rates among the least advantaged. Significance is determined if 95% CIs do not include 0.

Large negative values of the RII_{mean} indicate high levels of inequality with higher rates among the least advantaged. Significance is determined if 95% CIs do not include 0.

Large values of the RII_{ratio} indicate high levels of inequality. Significance is determined if 95% CIs do not include 0.

As the slope and relative index of inequality make use of a linear regression, the model should fulfill the basic assumptions associated with regression and linearity.[46] However, other forms of regression, such as a logistic regression, can be used if the assumptions of linearity do not hold.[12]

One important advantage of the SII and RII are that the measures are able to incorporate information on all the socioeconomic groups and the proportion of the population that they reflect. The regression measures are appropriate when one is seeking to measure how health varies with the amount of characteristic (for example with increasing SES) as opposed to comparisons between individual groups.[1] Like the PAF, the slope and relative index of inequality provide a measure of total population impact which accounts for the population size in each socioeconomic category. However, unlike the PAF, they do not require a clear monotonic gradient in the rate of the health outcome to be meaningful. The SII and RII can easily be converted between relative and absolute measures of inequality which may provide a better understanding of the magnitude of inequality. An advantage of using regression based measures is that standard diagnostic procedures can be used to determine model fit such as influential observations.[22] The interpretations of the SII and RII are both relatively intuitive, being very similar to well understood concepts in health science literature, the rate difference and the rate ratio.[1]

One limitation of using the SII and RII is that the SES variable must be measured on an interval scale. This can be problematic for some SES indicators which do not have obvious hierarchical structures such as occupation groups. Attempting to organize these SES indicators on an interval scale requires certain

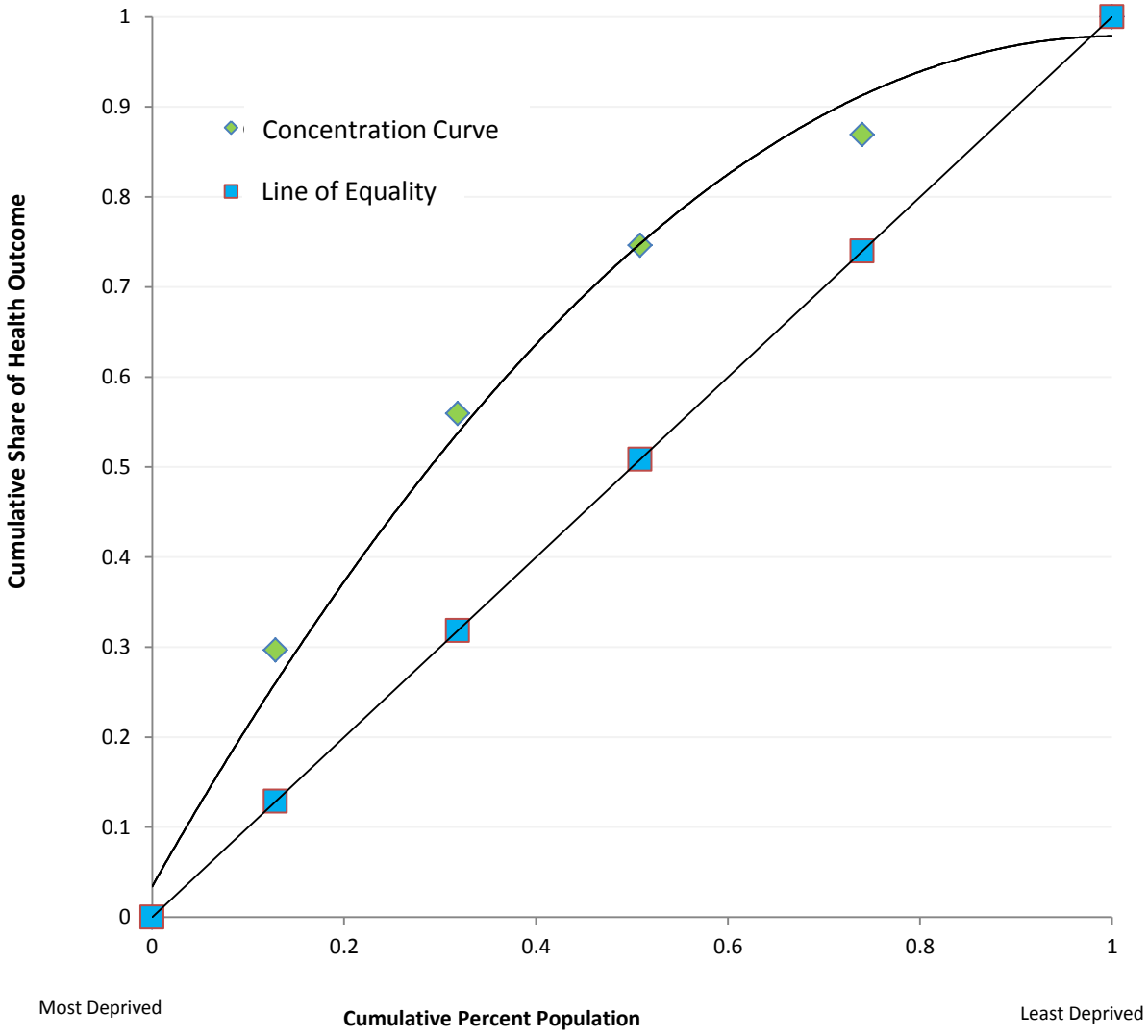
assumptions about the hierarchical relationship between the groups, which may result in certain biases.[5] Another disadvantage is that the measures can yield unreliable results when they are applied to small samples with aggregate data.[46] Additionally, the calculation of these measures and 95% confidence intervals requires the use of more sophisticated statistical software.[1] Finally, the interpretation is more complex than the range and PAF and therefore may be subject to misunderstandings.[5]

Applications where the RII and SII are most useful is when one is attempting to use a more rigorous method of measuring inequality which takes into account both the size of the population in the different socioeconomic groups and the effect size for all groups of the population. It is suggested to check less complex methods of measuring inequalities, such as the range and PAF against these regression based measures.[5] This method is useful if one is interested in how health varies with the amount of the characteristic, for example with increasing SES rather than between the groups themselves.[1]

HEALTH CONCENTRATION INDEX

The health concentration index (HCI), also known as the concentration index, is similar to a measure of inequality commonly used in economic literature known as the Gini coefficient.[37] The concentration curve models the cumulative share of the health outcome in the population against the cumulative share of the population, ranked by SES from lowest to highest. This curve is then compared to the line of equality which is the 45 degree line where the cumulative percent of the population equals the cumulative share of the health outcome. Figure 4 illustrates this comparison. The HCI is calculated as two times the area between the concentration curve and the line of equality, and can take on values between -1 and 1.[3]

Figure 4: Visual Depiction of the Health Concentration Index



An HCI significantly different from zero indicates the presence of an inequality. If the health outcome is more concentrated in the lowest socioeconomic groups, the concentration curve will be above the line of equality and the HCI will be negative. If the health outcome is concentrated in those with higher SES, the curve will be below the line of equality and the HCI will be positive.[3]

Calculating the Health Concentration Index

The HCI can be calculated using the formula:

$$C = (p_1 L_2 - p_2 L_1) + (p_2 L_3 - p_3 L_2) + \cdots + (p_{T-1} L_T - p_T L_{T-1})$$

Where *p* is the cumulative percentage of the population in the socioeconomic group (T) and L_t is the corresponding concentration curve ordinate.[37]

The HCI and the slope index of inequality are related by the following formula:

$$C = 2var(x)(\frac{\beta}{\mu})$$

Where C is the health concentration index, μ is the mean level of the health variable, var(x) is the variance of the relative rank variable and the slope coefficient *B* is taken from the regression for the SII.[3]

Interpreting the Health Concentration Index

Large negative values of the HCI indicate high levels of inequality with higher rates among the least advantaged. Significance is determined if 95% CIs do not include 0.

A major advantage of using concentration curves is that they provide an effective visual display of inequality in the population.[1] Similar to the RII and SII, the HCI also incorporates the intermediate socioeconomic groups as well as the distribution of the population between the groups, and thus satisfies Wagstaff et al.'s criteria for summary measures of inequality.[3] Another advantage of using concentration curves is the ability to measure dominance between two concentration curves (i.e., determine which curve represents a greater degree of inequality), thus providing a means of comparing inequalities between different populations. Dominance is determined if there is at least one significant difference between two curves in one direction and no significant differences between the curves in the other direction. If one concentration curve dominates the other, then one situation can be determined as having a greater degree of inequality. It is recommended when using this approach to adjust for multiple comparisons.[37]

A major disadvantage of the HCI is the absence of a straightforward and intuitive interpretation. Unlike the RII and SII which can be compared to frequently used metrics in public health, the HCI alone is not sufficient to understand inequality without an accompanying concentration curve.[1,46] An approach to

interpreting the HCI was developed by Koolman and Van Doorslaer.[49] This approach calculates the percent redistribution of the health outcome necessary from the most advantaged half to the least advantaged half of the population, in order to achieve equality (i.e., a health concentration index of zero). Another issue with using the HCI is the complexity involved in calculation. Most statistical software packages include simple functions for creating linear regression curves. However, this is not the case for creating concentration curves.[1] Furthermore, calculating measures of precision and controlling for confounders is more difficult when calculating the HCI.[5] As the HCI is mathematically related to the SII and RII, in certain cases, it may be more appropriate to use a simpler regression based measure.

The HCI is most useful when a more rigorous method of measuring inequalities, which takes into account both the distribution of the population between the different socioeconomic groups and the effect of low SES in all groups of the population, is required. This method is also useful for making comparisons of inequality, as one can calculate dominance between two concentration curves. In addition, the HCI is useful if one wishes to create an effective visual display of inequality in a population.[3]

Table 2: Summary Measures of Inequality

Measure	Relative/ Absolute	Advantages	Limitations	Useful Applications
The Range	Absolute and relative	Fast to calculate, easy to interpret Flexibility in groups being compared	Ignores middle socioeconomic groups and the population size of the socioeconomic groups	If no clear hierarchical structure between SES groups When rapid decisions are needed
Population Attributable Fraction	Relative	Considers all socioeconomic groups Demonstrates population burden of disease	Ignores information on relationship between SES and frequency of the health outcome Requires a linear gradient to be meaningful	When rapid decisions are needed When desirable to demonstrate the population burden of inequality
Slope and Relative Index of Inequality	Absolute and relative	Takes into account population income distribution and strength of effect	More complex calculation and interpretation, requiring sophisticated statistical software Requires an obvious hierarchical structure of SES variable	A more rigorous statistical method for calculating inequalities Use to check less complex methods of measuring inequalities
Health Concentration Index	Relative	Takes into account population income distribution and strength of effect Good visualization of health disparities	Difficult to calculate measures of precision and control for confounding No straightforward interpretation	A more rigorous statistical method for calculating inequalities Use to check less complex methods of measuring inequalities Making comparisons of inequality between populations Creating effective visual displays of inequalities

Working Application of Measures

A working application is presented illustrating the use of all the methods described in the previous chapter for measuring inequalities in Ontario and selected public health units. The working application has two purposes:

1) To describe the methods used to measure health inequalities, illustrating the use of measures of SES and summary measures of inequality
2) To examine the effectiveness of summary measures when applied to PHUs of various sizes and geographies, as well as individual vs. area based measures so that practical recommendations can be made.

The application examines socioeconomic inequalities in smoking, a health indicator known to vary by SES.[50,51]

Socioeconomic inequalities in smoking rates have been reported in the literature, with less advantaged groups tending to have higher rates of smoking.[50,51] Smoking, whose use is strongly related to SES, is considered the most significant modifiable risk factor contributing to health inequalities.[52] Inequalities in smoking may result from a number of social determinants including poor targeting of health information to disadvantaged groups, lowered self-esteem, and increased stress level.[52,53] Inequalities in smoking rates between social classes are important as they relate to socioeconomic inequalities in many poor health outcomes, including morbidity and mortality from cardiovascular disease, chronic obstructive pulmonary disease, and various cancers.[54,55] Understanding socioeconomic inequalities in smoking rates is therefore necessary as it is both an important outcome of social determinants of health as well as a strong contributor to inequalities in heath.

This report presents an analysis of inequalities in rates of current smoking at the provincial level and in selected PHUs in Ontario. The analysis will compare smoking inequalities using individual level data on SES (household income) as well as two ABSMs, a simple area based measure (QAIPPE) and a more complex measure (ON-Marg), to assess the strengths of the approaches in measuring inequalities. Additionally, the summary measures of inequality, described above, will be calculated and their use in measuring socioeconomic inequalities will be evaluated.

Data Sources

CANADIAN COMMUNITY HEALTH SURVEY

Data from the Canadian Community Health Survey (CCHS) 2009–10 cycle provided the individual level information, (i.e., smoking status, household income, demographic variables and geographic information). The CCHS is a national survey of the Canadian population aged 12 and over which is representative at the PHU level. The CCHS makes use of a complex stratified, and cluster sampling design to achieve representativeness. Excluded from the CCHS sampling frame are individuals living on Native Reserves and on Crown Lands, institutional residents, full-time members of the Canadian Forces, and residents of certain remote regions.[56] The 2009–2010 CCHS included 124,870 participants from across Canada, achieving a response rate of 72.3%. The share file contains a portion (>90%) of the original CCHS respondents. In Ontario, information on 40,403 individuals is available in the share file.[56] Participants of the CCHS were assigned a census dissemination area based on their postal code.

CANADIAN CENSUS

Two variables which made use of 2006 Canadian census data were used in this analysis: quintile of adjusted income per person equivalent (QAIPPE) and the Ontario Marginalization index (ON-Marg). The QAIPPE, derived from 2006 census data, is the neighbourhood income for a DA, adjusted for household size (i.e., the adjusted income per person equivalent (IPPE)), ranked and split into quintiles.[7]

The ON-Marg, an Ontario specific version of the Canadian Marginalization index (CAN-Marg) was also derived from 2006 census data. The ON-Marg contains four dimensions of marginalization: material deprivation, residential instability, dependency, and ethnic concentration.[57] The indexes of material deprivation and residential instability will be the focus of this analysis as they are more highly correlated with health outcomes.[6]

Formation of the Analytic Dataset

Statistics Canada QAIPPE and ON-Marg data for Ontario residents were linked to CCHS data using DA identification numbers. Participants were identified as current smokers if they defined themselves as smoking cigarettes occasionally or daily. Other CCHS variables examined as potential covariates were age, sex, education, ethnicity (recoded as white or non-white), immigrant status, marital status, urban or rural status, and attainment of post-secondary education. For the purpose of this analysis, SES level was identified as the exposure, while current smoking status was identified as the outcome of interest.

The study population was residents of Ontario, with a population size of approximately 13.0 million at the time of the survey. Four PHUs of varying population sizes, geographies, and urban/rural status were selected: PHU A is an urban/rural mix PHU with a large population of 400,000 (i.e., 390,000 above the age of 12, represented by the CCHS sample), PHU B is a sparsely populated urban/rural mix PHU with a very small population of 32,000 (i.e., 30,000 above the age of 12, represented by the CCHS sample), PHU

C is an urban/rural mix PHU with a small population of 180,000 (i.e.,165,000 above the age of 12, represented by the CCHS sample), and PHU D is a metro centre with a population of 2.6 million (i.e., 2.34 million above the age of 12, represented by the CCHS sample.[52,58] The analysis was performed at the level of the selected PHUs and for the province of Ontario.

Statistical Analysis

The weighted population size by SES quintile for each geographic unit was computed using the SAS procedure surveymeans. The total number of smokers was similarly calculated as the weighted number of smokers in a PHU using the SAS procedure surveyfreq. Weighted rates of current smokers and variance estimates for each SES quintile and for each geographic unit were calculated through bootstrapping, using a SAS macro provided by Statistics Canada. The proportions of select socio-demographic variables by SES quintile were calculated using proc surveyfreq.

The summary measures of inequality, described above, were computed for smoking rates across each of the measures of SES (household income quintile, QAIPPE, ON-Marg material deprivation, and residential instability).The area-based measures of QAIPPE, material deprivation, and residential instability were compared against the individual-based measure of household income quintile. The summary measures calculated were the range, the PAF, the SII, the RII, and the HCI.

An excel program created by Scotland Public Health Observatory (ScotPHO) was adapted to calculate all of the listed summary measures of inequality, using methods described in the summary measures section (adapted ScotPHO program available from Public Health Ontario upon request).[47] Data on population size and rates of smoking, both by SES quintile and overall, were required in the calculation of point estimates for the summary measures of inequality. Calculation of the absolute number of smokers related to income inequality additionally required providing the total number of smokers per geographic unit. The excel file does not include calculations for measures of precision. Appendix C provides a description of the excel program and how it can be used in the calculation of summary measures of inequality.

The DRR and the AD with 95% confidence intervals were calculated using formulae provided by Cheng et al.[48] However, no adjustment was made for multiple comparisons.[48] The formula for calculating the PAF and 95% confidence intervals was provided by CIHI. SII and RII values with 95% confidence intervals were calculated using the SAS procedure reg, and the formulae provided by Cheng et al.[48] for calculating measures of precision.[48] Methods of calculating 95% confidence intervals for the health concentration index are more complex and are not presented in this report. However, methods of calculation, including a SAS macro are presented in Cheng et al.[48] SAS syntax for calculating the DRR, PAF, SII and RII with 95% CIs is available upon request.

Demographic Information

In Ontario, information on 40,403 individuals is available in the CCHS 2009–10 share file. The survey was completed by 1385 respondents in PHU A, 359 respondents in PHU B, 919 respondents in PHU C, and 3493 respondents in PHU D. Self-reported data from the CCHS showed that 19% of Ontario residents were current smokers. The population was composed of 49% males and 51% females, with a mean age of 44 years. The rate of selected socio-demographic variables by socioeconomic group for each of the measures of SES (income quintile, QAIPPE, ON-Marg material deprivation, and ON-Marg residential instability) as well as the proportion of the population that falls into each socioeconomic category is found in Appendix D.

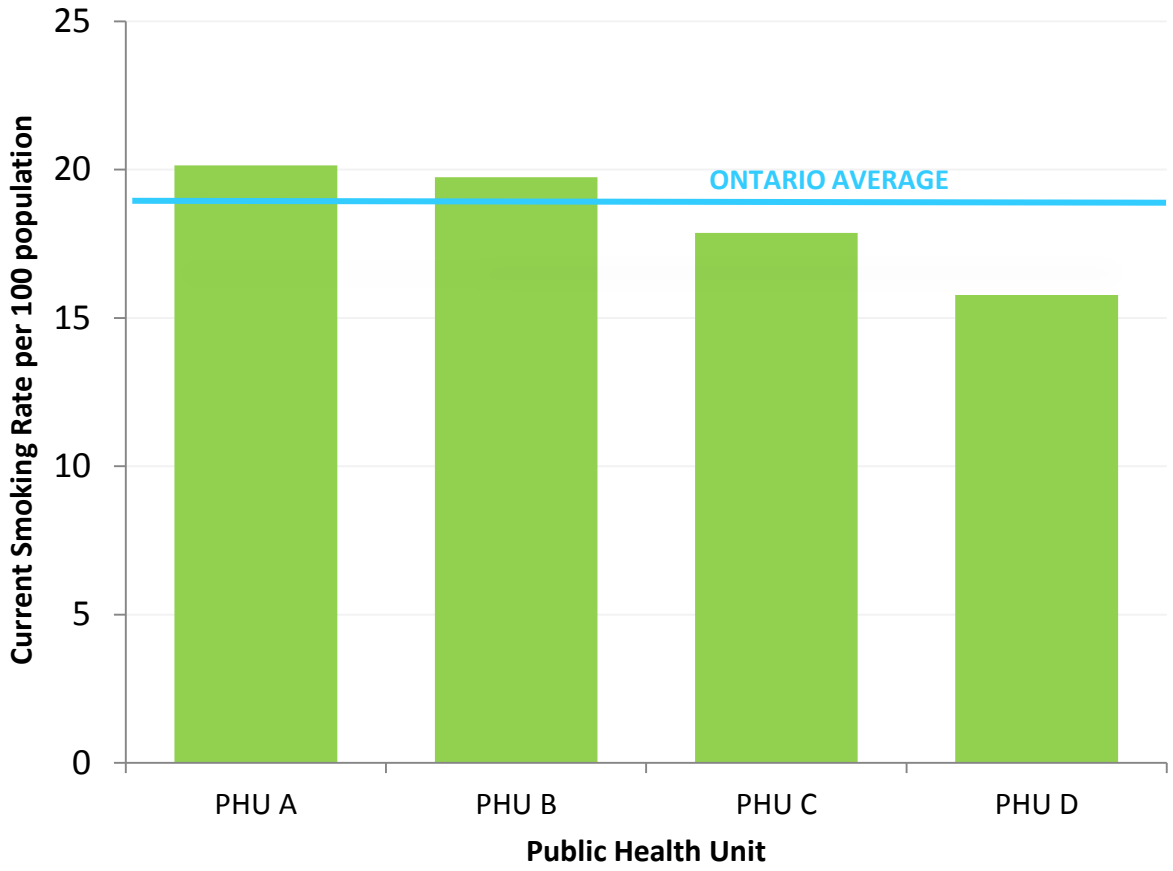
Missing information was much more common for individual level household income (19%) as opposed to area-based measures (ranging from 0.2–0.8%) (see Appendix D for details). Those with missing information for household income had socio-demographic profiles which resembled lower income quintiles. The population appeared to be evenly split between quintiles by household income as well as quintiles by QAIPPE. However, for the ON-Marg indexes, of material deprivation and residential instability, a greater proportion of the population was found in the more advantaged quintiles and a smaller proportion in the least advantaged quintiles.

Average age composition was found to be consistent across socioeconomic groups. With the exception of quintiles of residential instability, the following trends were observed: male sex, white ethnicity, married individuals, and individuals with post-secondary education were overrepresented in more advantaged quintiles, while immigrants and residents of urban areas were under-represented in more advantaged quintiles. For residential instability quintiles, married individuals (not including common-law) were under-represented among more marginalized groups, while urban status was highly overrepresented among the most marginalized groups.

Smoking Rates in Ontario and Selected PHUs

Current smoking rates in Ontario and selected PHUs are shown in Figure 5. Smoking rates in PHU C and PHU D were lower than the Ontario average, while rates in PHU A and PHU B were higher. PHU A, where just over 20% of the population were found to be current smokers, showed the highest smoking rates.

Figure 5: Current smoking rates in Ontario and selected PHUs, 2009–10



Rates of current smoking for different SES measures in Ontario are shown in Figure 6. A clear gradient was found for all SES measures whereby smoking rates were higher in more deprived SES quintiles.

Figure 6: Current smoking rates by different SES measures in Ontario, 2009–10

Figure 6-A: Smoking Rates by Household Income Quintile in Ontario

Figure 6-B: Smoking Rates by QAIPPE in Ontario

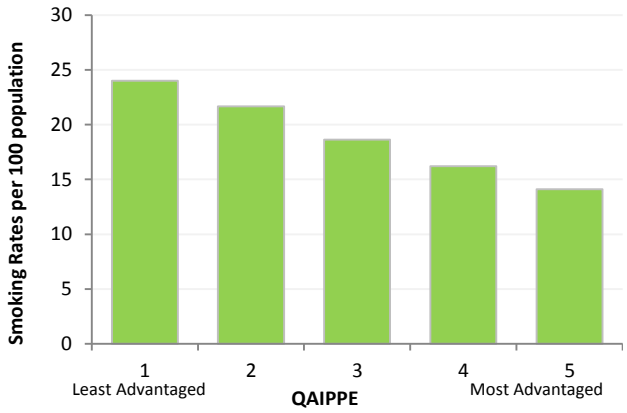


Figure 6-C: Smoking Rates by ON-Marg Material Deprivation Quintile in Ontario

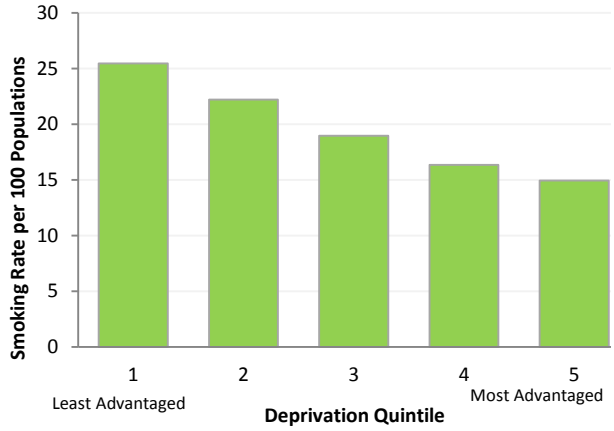
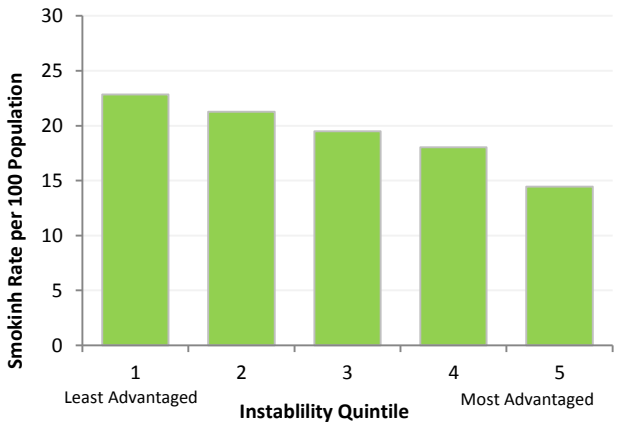


Figure 6-D: Smoking Rates by ON-Marg Residential Instability Quintile in Ontario



Rates of current smoking by socioeconomic group in Ontario and various PHUs are displayed in Appendix E. In general, a clear gradient was found whereby smoking rates were higher in more deprived SES quintiles.

In all health units and for all groupings by SES, the rate of smoking was greater in the most deprived quintile as opposed to the least deprived.

Summary Measures

Table 3 displays values calculated for each of the summary measures of inequality for the different SES measures and the different PHUs of interest.

Table 3: Summary Measures of Inequality by PHU and by SES measure, 2009–10

	The Range			The Indexes of Inequality			
	DRR (95% CI)	AD (95% CI)	PAF (%) (95% CI)	SII (95% CI)	RIImean (95% CI)	RIIratio (95% CI)	HCI
Ontario							
Income Quintile	1.82 (1.61 – 2.03)	11.43 (9.25 – 13.60)	27.35 (21.39 – 32.94)	-12.37 (-21.38 – -3.37)	-0.66 (-1.14 – -0.18)	1.95 (1.14 – 3.33)	-0.103
QAIPPE	1.70 (1.46 – 1.94)	9.89 (7.69 – 12.08)	24.89 (17.79 – 31.30)	-12.70 (-14.46 – -10.95)	-0.67 (-0.77 – -0.58)	2.02 (1.82 – 2.24)	-0.11
Material Deprivation Quintile	1.70 (1.45 – 1.96)	10.53 (8.01 – 13.05)	20.53 (13.18 – 26.50)	-12.86 (-18.29 – -7.43)	-0.68 (-0.97 – -0.39)	2.04 (1.47 – 2.82)	-0.11
Residential Instability Quintile	1.58 (1.28 – 1.88)	8.38 (6.00 – 10.76)	23.24 (17.00 – 29.12)	-10.67 (-13.35 – -8.00)	-0.57 (-0.71 – -0.43)	1.79 (1.53 – 2.09)	-0.09
PHU A: Large, urban/rural mix							
Income Quintile	3.88 (3.22 – 4.54)	21.45 (12.27 – 30.62)	63.17 (41.21 – 77.45)	-26.09 (-43.34 – -8.84)	-1.30 (-2.15 – -0.44)	4.56 (1.04 – 19.95)	-0.21
QAIPPE	5.77 (5.26 – 6.28)	31.76 (21.82 – 41.70)	66.69 (50.83 – 77.75)	-38.56 (-63.70 – -13.41)	-1.91 (-3.16 – -0.67)	72.28 (0.00 – 2.07E8)	-0.31
Material Deprivation Quintile	4.60 (4.02 – 5.17)	36.45 (24.93 – 47.97)	49.43 (22.83 – 67.81)	-40.87 (-74.99 – -6.75)	-2.03 (-3.72 – -0.34)	*-179.58 (..–..)	-0.31
Residential Instability Quintile	2.14 (1.34 – 2.94)	16.03 (5.31 – 26.74)	30.81 (-3.80 – 54.94)	-22.67 (-36.91 – -8.44)	-1.13 (-1.83 – -0.42)	3.50 (1.24 – 9.85)	-0.18

	The Range			The Indexes of Inequality			
	DRR (95% CI)	AD (95% CI)	PAF (%) (95% CI)	SII (95% CI)	RIImean (95% CI)	RIIratio (95% CI)	HCI
PHU B: Sparsely Populated urban/rural mix							
Income Quintile	1.80 (0.00 v 4.10)	6.70 (-7.28 – 20.68)	53.50 (-9.33 – 82.13)	-11.36 (-68.26 – 45.54)	-0.58 (-3.46 – 2.31)	1.89 (0.08 – 43.78)	-0.09
QAIPPE	1.01 (0.00 –99.82)	0.150 (-14.35 – 14.64)	-2.59 (-51.42 – 35.67)	5.10 (-56.99 – 67.18)	0.26 (-2.89 – 3.40)	0.80 (0.03 – 19.59)	0.01
Material Deprivation Quintile	1.21 (0.00 – 5.43)	4.14 (-13.15 – 21.42)	10.08 (-46.68 – 49.65)	-4.84 (-28.13 – 18.45)	-0.25 (-1.12 – 0.63)	1.24 (0.51 – 3.01)	-0.04
Residential Instability Quintile	1.14 (0.00 – 11.52)	2.52 (-23.65 – 28.70)	15.96 (-42.81 – 55.05)	-5.73 (-47.85 – 36.39)	-0.29 (-2.42 – 1.84)	1.29 (0.15 – 11.39)	-0.03
PHU C: Small, urban/rural mix							
Income Quintile	2.33 (1.42 – 3.24)	17.87 (5.89 – 29.84)	20.33 (-24.67 – 52.98)	-17.65 (-44.55 – 9.26)	-0.99 (-2.49 – 0.52)	3.23 (0.44 – 23.63)	-0.15
QAIPPE	2.49 (1.50 – 3.47)	14.22 (3.19 – 25.26)	45.81 (6.32 – 70.09)	-20.53 (-31.29 – -9.78)	-1.15 (-1.75 – -0.55)	3.76 (1.53 – 9.22)	-0.18
Material Deprivation Quintile	1.94 (1.10 – 2.78)	10.94 (2.81 – 19.07)	34.92 (9.00 – 55.17)	-16.17 (-38.58 – 6.24)	-0.90 (-2.16 – 0.35)	2.61 (0.54 – 12.64)	-0.15
Residential Instability Quintile	1.51 (0.00 – 3.13)	8.37 (-4.35 – 21.08)	9.15 (-38.74 – 44.33)	-9.75 (-26.11 – 6.61)	-0.55 (-1.46 – 0.37)	1.76 (0.66 – 4.74)	-0.09
PHU D: Large, metro centre							
Income Quintile	1.44 (0.29 – 2.59)	4.45 (-0.45 – 9.36)	39.20 (16.16 – 56.46)	-4.22 (-31.49 – 23.04)	-0.27 (-2.00 – 1.46)	1.29 (0.22 – 7.48)	-0.03
QAIPPE	1.56 (0.72 – 2.39)	5.73 (1.25 – 10.21)	34.51 (13.86 – 50.78)	-5.55 (-22.24 – 11.15)	-0.35 (-1.41 – 0.71)	1.42 (0.48 – 4.23)	-0.05
Material Deprivation Quintile	1.46 (0.29 – 2.63)	5.38 (-0.58 – 11.34)	25.42 (-3.43 – 47.17)	-6.76 (-13.98 – 0.46)	-0.43 (-0.89 – 0.03)	1.55 (0.96 – 2.50)	-0.07
Residential Instability Quintile	2.25 (1.52 – 2.98)	10.16 (4.74 – 15.58)	48.09 (16.42 – 68.24)	-10.18 (-21.91 – 1.55)	-0.65 (-1.39 – 0.10)	1.95 (0.85 – 4.47)	-0.09

*light green shading represents significant results

The summary measures were generally consistent with one another. In particular, the health concentration index was highly consistent with the index of inequality measures. The PAF tended to be less consistent with other summary measures of inequality. The SII as an absolute measure of inequality showed similar results to the absolute difference but generally seemed to provide a higher value compared to the absolute difference. The RII_{ratio} appeared very unstable in measuring inequalities, particularly when the difference in smoking rates between the most and least deprived group was very high, such as for PHU A (Large, urban/rural mix). The DRR and RII_{ratio} both represent a ratio of rates between the most and least advantaged. The RII_{ratio} generally overestimated inequality as compared to the DRR. Significant health inequalities were found in Ontario across all summary measures and across all measures of SES. The confidence intervals for the slope and relative index of inequality tended to be wide as compared to the range measures. Therefore, fewer significant results were found according to the index of inequality measures as compared to the range measures.

SUMMARY MEASURES ACROSS ONTARIO AND PHUs

For the province of Ontario, disparities in smoking rates, as measured by the DRR and AD, were significant for all measures of SES. Differences in smoking rates ranged from 58% greater rates in the most deprived as opposed to the least deprived quintile, or a difference in rates of 8.38 per 100 population, when measuring SES according to residential stability, to 82% greater rates in smoking, or an increased rate of 11.43 per 100 population, in the most deprived quintile, when SES was measured according to income quintile. According to the range measures, the greatest inequalities in smoking by SES were observed in PHU A, with measured differences in smoking rates ranging from a 2.14 times higher rate (in the most deprived as compared to the least deprived), or a difference in rates of 16.03 per 100 population, when SES was measured according to residential instability, to 5.77 times higher smoking rates, or a difference of 31.76 per 100 population, when measured according to QAIPPE. Much of the data for PHU B were not releasable due to extreme sampling variability and no significant inequalities were found. Inequalities were found to be significant in PHU C (small, urban/rural mix) for all measures of SES except residential instability. For PHU C, an approximate two fold increase in the rate of smoking in the most deprived as opposed to the least deprived quintile was demonstrated for all SES measures, with differences in rates between the least and most advantaged ranging from 8.37 per 100 population (by quintile of residential instability) to 17.87 per 100 population (by household income quintile). The smallest values for health disparities were found in PHU D (Large, metro centre). However, a large and significant value was found for residential instability, where those living in neighbourhoods with the highest residential instability had over twice (i.e., 2.25) the smoking rate or a difference in rates of 10.16 per 100 population, as compared to those living in neighbourhoods with the lowest residential instability.

Across the PHUs, significant PAFs were found in PHU A for all measures of SES, except residential instability which showed lower levels of inequality across all summary measures. For PHU C, PAF was significant for QAIPPE and deprivation quintile, but not for income quintile, which was significant according to the DRR and AD measures. For PHU D, PAF values were significant for all measures of SES

except material deprivation quintile though significant inequalities were not found for income quintile and QAIPPE according to the DRR and AD.

Across the PHUs, significant health inequalities for the slope and relative index of inequality were found in PHU A according to all measures of SES, and in PHU C for inequalities measured by QAIPPE. Other disparities measured to be significant in PHU C, according to the DRR and AD, were not found to be significant according to the index of inequality measures.

SUMMARY MEASURES ACROSS DIFFERENT MEASURES OF SES

Figure 7 shows linear regressions modelling smoking rates against the cumulative share of the population in Ontario for different measures of SES. For all measures of SES the slopes of the regression models (indicating the SII) appear very similar.

Figure 7: Smoking Rates by Population Share, by Different SES Measures in Ontario, 2009–10

Figure 7-A: Household Income Quintile

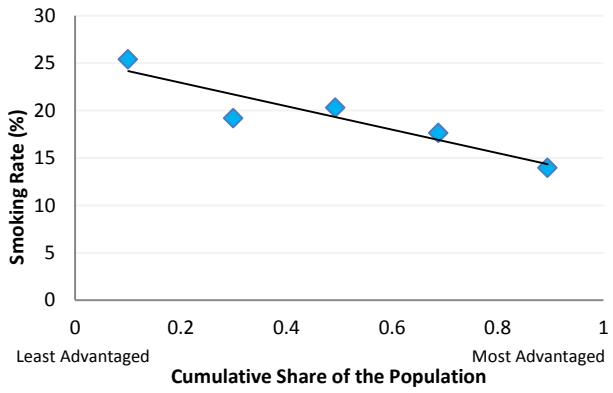


Figure 7-B: QAIPPE

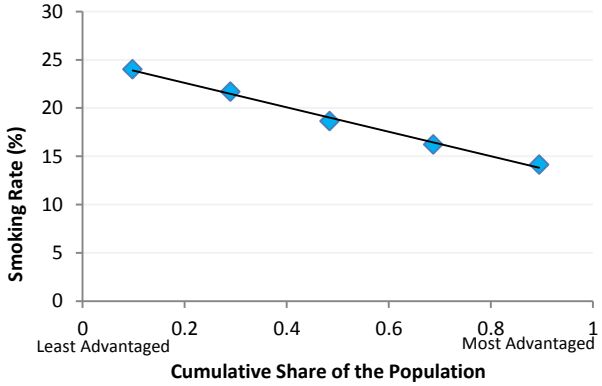


Figure 7-C: ON-Marg Material Deprivation Quintile

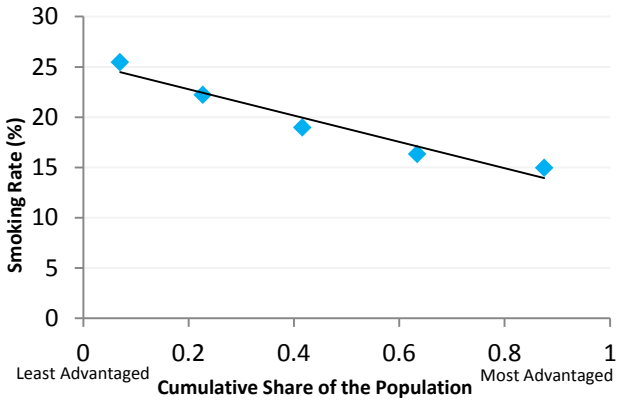
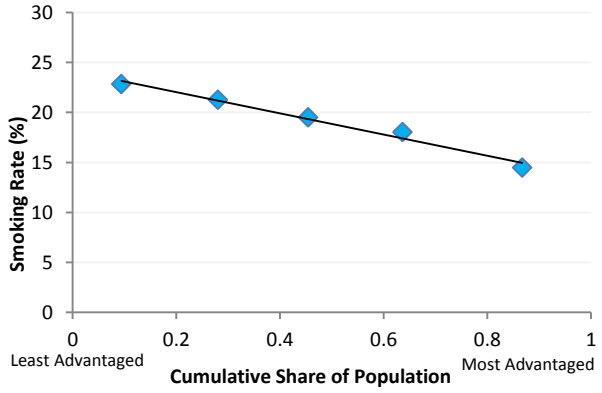


Figure 7-D: ON-Marg Residential Instability Quintile



The concentration curves, compared against the line of equality are displayed in figure 8 for different measures of SES in Ontario. The concentration curves show similar degrees of inequality across all measures of SES in Ontario.

Figure 8: Concentration Curves by Socioeconomic Measures in Ontario, 2009–10

Figure 8-A: Household Income Quintile

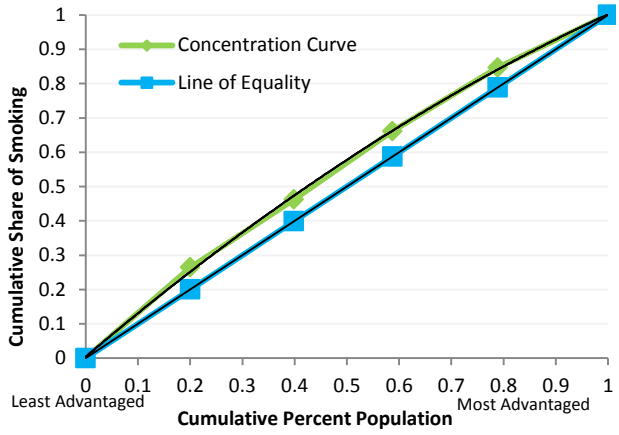


Figure 8-B: QAIPPE

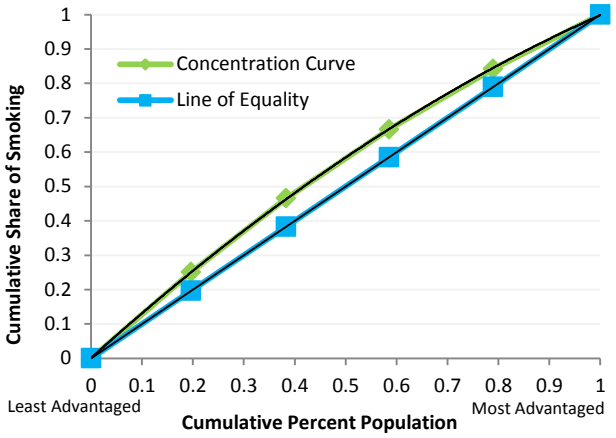


Figure 8-C: ON-Marg Material Deprivation Quintile

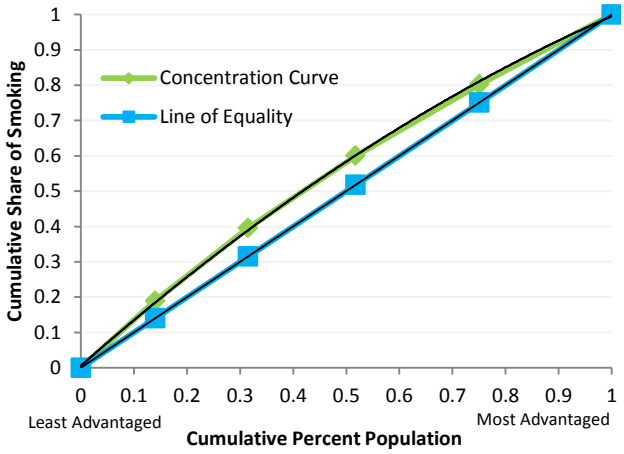
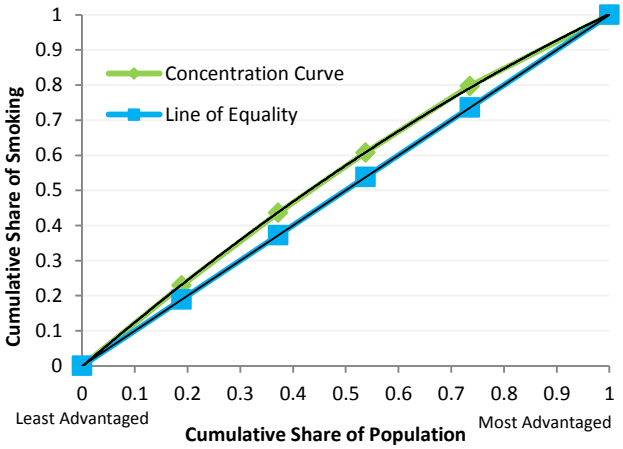


Figure 8-D: ON-Marg Residential Instability Quintile



Summary measures calculated according to individual income quintile, QAIPPE, and material deprivation showed similar patterns of inequality. However, inequality according to level of residential instability appeared to be less associated with the other three measures of SES, and tended to provide a lower estimate of inequality. Summary measures calculated for the province of Ontario demonstrated very similar results across the different SES measures. Summary measures calculated at the PHU level were much more variable. The ABSMs, QAIPPE and material deprivation, tended to show a greater degree of

inequality compared to inequality measured by household income quintile; this result was shown consistently for the QAIPPE measure but was more variable for inequality as measured by material deprivation.

Analysis Limitations and Strengths

Limitations of the analysis include insufficient CCHS sample size to generate interpretable results for some PHUs. For example, the datasets for PHU B (small population, sparsely populated urban/rural mix) and PHU C (small population, urban/rural mix) contained 359 and 919 respondents respectively. The number of smokers in each socioeconomic group was often small, particularly for the more advantaged socioeconomic groups where smoking rates were low. For most data at the PHU level, high sampling variability, (i.e., coefficient of variation>16.6) requires that results are interpreted with caution. For PHU B, most smoking rates and measures of inequality were not releasable due to extreme sampling variability (coefficient of variation >33.3).

The time period used to measure individual smoking (2009–10) is different from the time period used in the calculation of the ABSMs (derived from the 2006 census). This is an important limitation which reduces comparability between area based and individual measures of SES, as smoking rates have been decreasing and individual level income may change over time. Another concern is the self-reported nature of the data which could result in an under- or over-reporting bias. For example, due to social desirability, people may under-report smoking habits. This could bias results if under-reporting of smoking differs between socioeconomic groups. Another issue with the CCHS dataset is the high number of subjects with missing information on income. For Ontario overall, information on income is missing for 19% of respondents. This could importantly bias results if those with missing information on income have characteristics which relate to risk of smoking. Those who did not provide information on income were found to resemble those in more deprived income quintiles. However, all significant inequalities found by household income quintile were also significant when measured by ABSMs, for which missing information was not a major concern (missing information ranging from 0.2 – 0.8% of respondents).

This analysis did not adjust for potential confounders such as age, sex and ethnicity. However, socio-demographic profiles showed that some of these variables differed between socioeconomic groups. Some of these variables are shown in the literature to be related to increased risk of smoking, including male sex, white ethnicity, and lower educational attainment.[50,51,59-61] Therefore, confounding may contribute to the relationship observed between SES and smoking. Future analyses could use age and sex standardized rates when calculating summary measures of inequality as well as adjusting for other potential confounders such as ethnicity. Calculation of the index of inequality measures rely on the assumption of linearity. A linear association seems to hold for smoking rates by SES for Ontario. However, at the PHU level, a linear model did not fit the data as well.

Strengths of this study include the large, representative sample size for Ontario. The larger sample size allowed for sufficient power to detect significant inequalities by SES for the province of Ontario overall.

Because the CCHS data are representative at the PHU level, inferences could be made to PHUs. Another strength of the study was the use of multiple measures of SES, which allowed for comparisons to be made and potential biases to be identified relating to the use of area based SES data. Similarly, the use of multiple summary measures of inequality allowed for comparisons and the identification of potential biases relating to the use of the different summary measures.

Discussion

This report aimed to identify summary measures which could be used effectively in the identification of health inequalities by SES. A review of the literature identified five commonly used summary measures of health inequalities: the range, the PAF, the SII, the RII, and the HCI. All of these summary measures have been employed in the scientific literature to measure health inequalities, as well as being identified as important summary measure of health inequalities in reviews of the literature,[3,5] and practical guides by governing and surveillance bodies [1,8,47,62]. The summary measures identified in this report are limited to already available commonly used measures of health inequalities. However, each of these measures has been well researched with a body of literature to support their use. Additionally, the common strengths and limitations of these measures are well understood and therefore could be assessed in this report.

Following the recommendation made by Keppel et al.,[1] summary measures provided include both absolute and relative measures of inequality to give a full description of the extent of inequalities. Certain summary measures have absolute and relative forms (i.e., the range and the SII/RII). Additionally, measures which would be relevant from a decision-makers perspective such as the PAF are provided which give context to inequalities in health. As each summary measure has different strengths and limitations in measuring inequalities, consideration should be given to providing more than one summary measure, if possible. In particular, providing both an absolute and relative measure of inequality provides a more complete understanding of the magnitude of the inequalities.[1,5]

Health inequalities were found to be significant across all summary measures for the province of Ontario for all measures of SES. When applied to an analysis of smoking inequalities by SES in Ontario overall and for selected PHUs of various sizes and geographies. Results suggest that the index of inequality measures are very effective at identifying inequalities when the sample size is large and the average rate of the health outcome is high. However, the more simple measures of inequality, such as the range, effectively identify inequalities where the population is small and the rate of the health outcome is lower.

Effect sizes were highly variable between different summary measures and different measures of SES. This suggests that for PHUs with small populations, computing summary measures of inequality may present a challenge. This problem may be overcome through combinations of CCHS cycles to achieve greater sample sizes.

In general, the summary measures of inequality were found to be consistent with one another, particularly, the slope and relative index of inequality and the HCI. This is expected as the index of inequality measures and the HCI are related through a simple equation.[3] Therefore, either of these complex measures can be chosen to provide a more rigorous method of measuring health inequalities. Choice of measure may depend on personal preference or the intention of the analysis. While, it is easier to calculate measures of precision and control for confounding for the SII/RII measures, the HCI

provides a very effective visual display of inequalities. The range measures were also shown to be consistent with the SII and the RII_{ratio}. This relationship was observed despite the fact that the range does not consider the distribution of the population across socioeconomic groups and the status of the in-between socioeconomic groups.[5,11] Because socioeconomic groups were divided into quintiles, splitting the population of Ontario fairly equally between socioeconomic groups (though more advantaged quintiles contained a larger proportion of the population when using the ON-Marg indexes), differences between the range measures and the index of inequality measures were reduced. However, the SII does seem to provide a higher estimate than the absolute difference even when the population groups are roughly equivalent and when the health gradient is clearly linear. The RII_{ratio} generally provided a higher estimate than the DRR as predicted in the literature.[1,48] . Another potential issue arises from the use of the RII_{ratio} which provided very unstable estimates when inequalities were large. Therefore, caution is recommended when using the RII_{ratio} as a summary measure of inequality. The PAF was generally less consistent with other measures of inequality. Therefore, providing the PAF along with another summary measure is important when describing inequalities.

There is a debate in the literature discussing whether ABSMs provide an appropriate proxy for individual level socioeconomic information. As described by Geronimus and Bound,[43,63] ABSMs can overestimate individual level effects when there is an additional contextual effect of area level SES on health outcomes. In this analysis, there was likely a strong contextual effect of area-level SES as ABSMs generally provided a higher estimate as compared to individual-level effects. This effect was found despite a possible non-differential misclassification bias, (i.e., area level deprivation does not always correctly identify individual level deprivation), which would tend to bias results towards the null.[43,63] The strong effect of area level factors on smoking rates may reflect the heavy influence of social context and peer groups on the decision to smoke.[44] It is therefore clear that providing area-level information on SES helps to inform the study of health inequalities. It also suggests that ABSMs can help to identify areas where the population is at increased risk of poor health outcomes. Caution is advised when using ABSMs as a proxy for individual level data, as differences in summary measures were observed.

Determining the presence of a health inequality is a first step in identifying an inequity. Examining the causes and context of a health inequality can help to determine whether it is an inequity and whether it is socially produced. Therefore, the technical process of measuring health inequalities is one step in identifying a priority population, (i.e., a population at increased risk), for which to target public health programs and services.

In conclusion, measuring health inequalities at the public health unit level is a first step in fulfilling the OPHS requirements of identifying health inequalities and priority populations. Health inequalities can be examined using various individual measures and area-based measures of SES.

Each of the summary measure of inequality displays a different dimension of inequality. The more complex measures such as the slope and relative index of inequality and the HCI provide a more accurate assessment of inequality as they consider the distribution of inequalities between socioeconomic groups and the health outcomes in the middle income groups.[3] These measures can be used to compare inequalities over time and between populations with different socioeconomic

distributions. However, as demonstrated in this analysis, the more complex measures may fail to detect an effect when sample sizes are small. The range and PAF measures are both quick and easy to calculate and provide information that is easily interpretable for other public health professionals as well as decision-makers. Visual displays of information, such as the concentration curve, may also be useful when advising decision-makers and other public health professionals. The choice of methodology will depend on a number of factors including the data available and the research question or intended purpose of the analysis. This report explores the commonly used summary measures to aid public health epidemiologists in establishing a sound scientific and technical process for analyzing inequalities. A framework which aids in choosing measures, such as a decision-making table may be a future product that can be used in the measure of inequalities at the provincial and PHU level.

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Appendix A: Literature Review Search Strategy

Search strategy: MEDLINE (indexed records)

#	Searches	Results
1	Socioeconomic Factors/ or Health Status Disparities/ or Healthcare Disparities/ or Social Justice/ or Vulnerable Populations/ or Minority Groups/	128020
2	*Health Status Indicators/ or *Population Surveillance/methods or *Statistics as Topic/ or *Health Surveys/methods	31252
3	1 and 2	1684
4	*Socioeconomic Factors/ or *Health Status Disparities/ or *Healthcare Disparities/ or *Social Justice/ or *Vulnerable Populations/ or *Minority Groups/	25648
5	Health Status Indicators/ or Population Surveillance/methods or Statistics as Topic/ or Health Surveys/methods	97781
6	4 and 5	1179
7	3 or 6	2238
8	("News" or "Letter" or "Comment" or "Editorial").pt.	1348738
9	exp Africa/ or exp Asia/ or exp Caribbean Region/ or exp Central America/ or exp Gulf of Mexico/ or exp Latin America/ or exp South America/ or exp Europe, Eastern/	865905
10	8 or 9	2157748
11	7 not 10	1466
12	limit 11 to english language	1312

Search strategy: MEDLINE (non-indexed records)

#	Searches	Results
1	(((health or social or socioeconomic$ or economic$ or access$ or service$ or impact$ or intervention$) adj3 (equalit$ or equit$ or determinant$ or disparit$ or inequality$ or inequit$)) or ((priorit$ or minorit$ or vulnerab$ or disadvantage$ or marginal$ or underserv$ or under-serv$ or depriv$ or high risk or hard-to-reach) adj3 (group$ or population$))).mp.	75783
2	(indicator$ or measure$ or monitor$ or metric$ or index$ or indices or instrument$1 or variable$ or surveillance).ti. or (indicator$ or measure$ or monitor$ or metric$ or index$ or indices or instrument$1 or variable$ or surveillance).ab. /freq=3	816203
3	1 and 2	6554
4	limit 3 to ("in data review" or in process or "pubmed not medline")	416
5	limit 4 to english language	397

Search terms: health equity and indicators

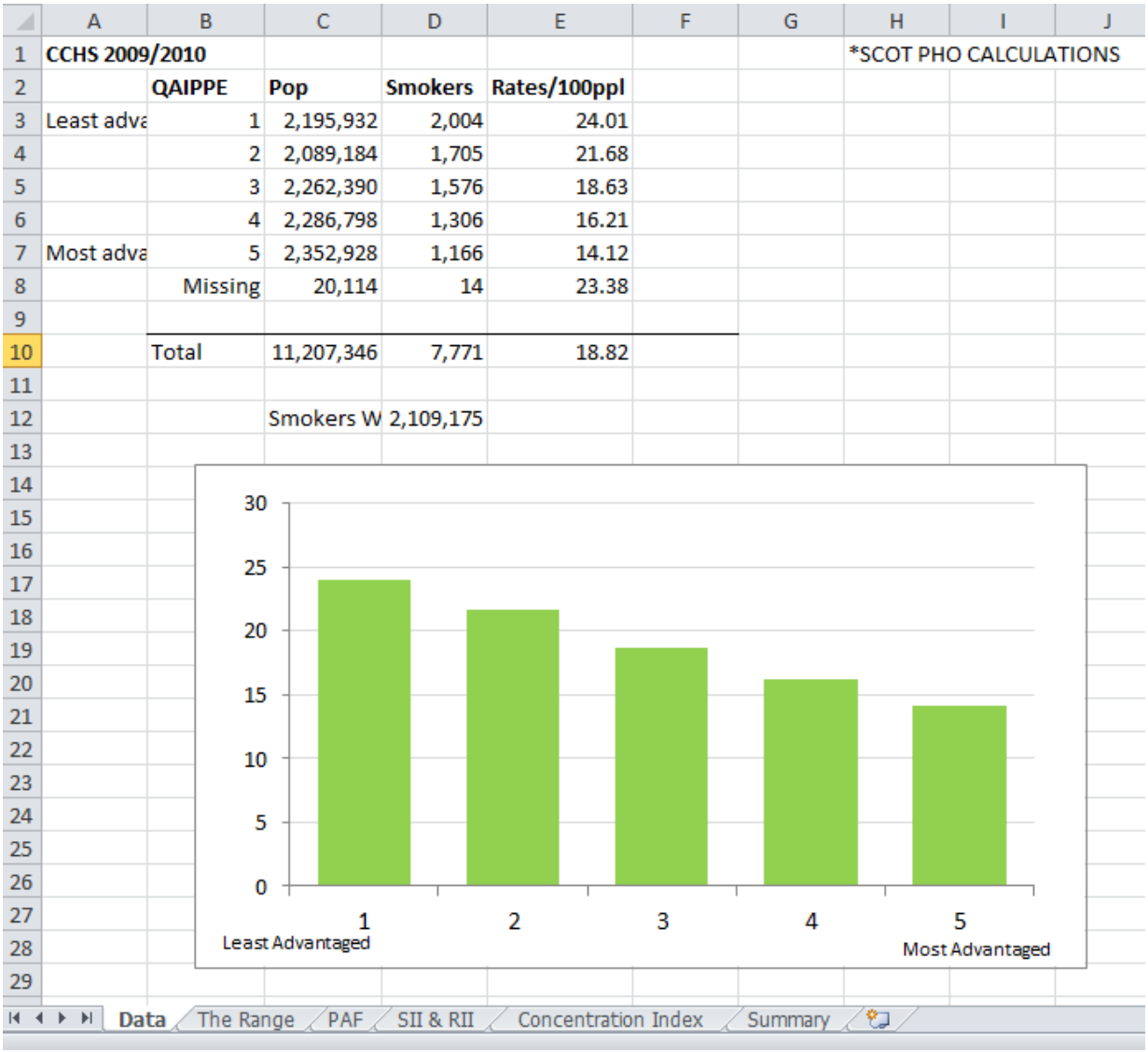
	Indicators	Health equity
MEDLINE subject headings (MeSH)	Health Status Indicators/ Health Surveys/ Population Surveillance/methods Statistics as Topic/	Socioeconomic Factors/ Health Status Disparities/ Healthcare Disparities/ Social Justice/ Vulnerable Populations/ Minority Groups/
Keywords	indicator$ measure$ monitor$ metric$ index$ indices instrument$1 variable$ surveillance	equalit$ equit$ determinant$ disparit$ inequality$ inequit$ disadvantage$ priorit$ minorit$ marginal$ underserv$ under-serv$ vulnerab$ minority group deprivs$ hard-to-reach high risk

Appendix B: Excel SES Summary Measure Calculator

The ScotPHO Excel program uses data on rates of a health outcome by SES group to calculate summary measures of inequality. This program analyzes populations divided into five SES groups.
Data is entered in the Data Tab on the first page of the program. Data should be entered according to SES quintile with the most deprived quintile entered at the top and the least deprived quintile at the bottom. Variables in the data tab include: population size per SES quintile, which should be weighted to account for the total population represented by the quintile, number of respondents with a particular health outcome, though this data is not used in calculations of the summary measures, and rates of the health outcome by population group, this data should be calculated with complex survey designs accounted for, and could be age and sex standardized.[47] Additionally, one should enter the total number experiencing the health outcome in the population.

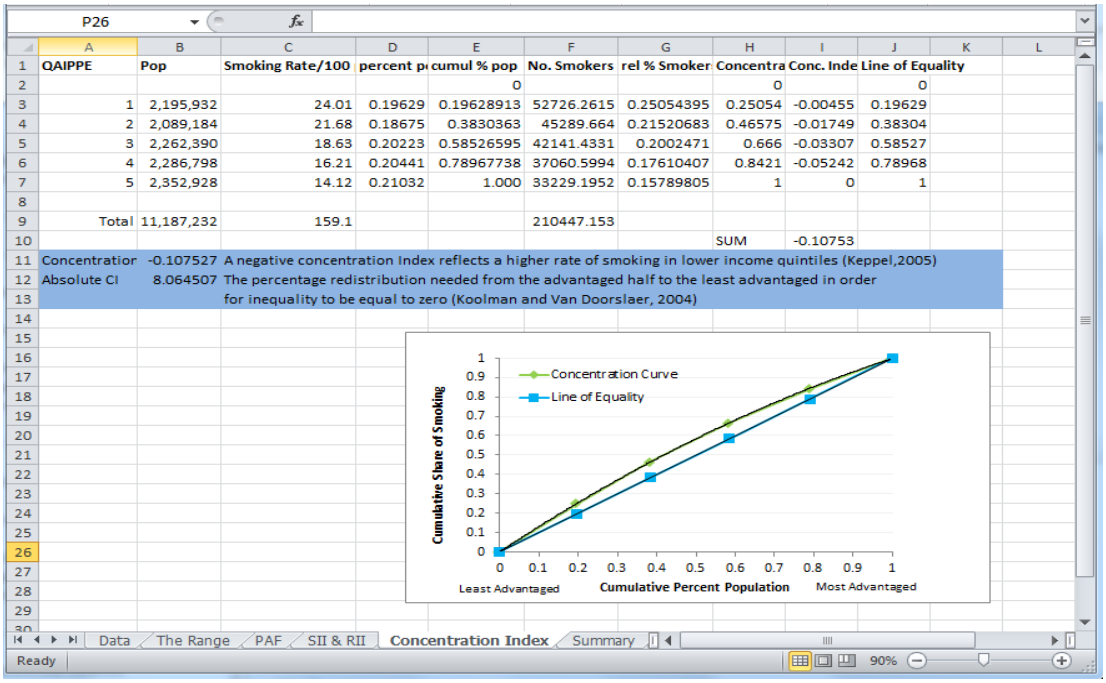
The population by quintile should be entered under "Pop" in column C, the number of respondents experiencing the health outcome in column D, and the rate of the health outcome per 100 people under "Rates/100ppl" in column E. The total number of experiencing the health outcome should be entered in cell D12, and the overall rate of the health outcome in the population in cell E10.

Figure B1: Data Tab, Ontario 2009–10 by QAIPPE



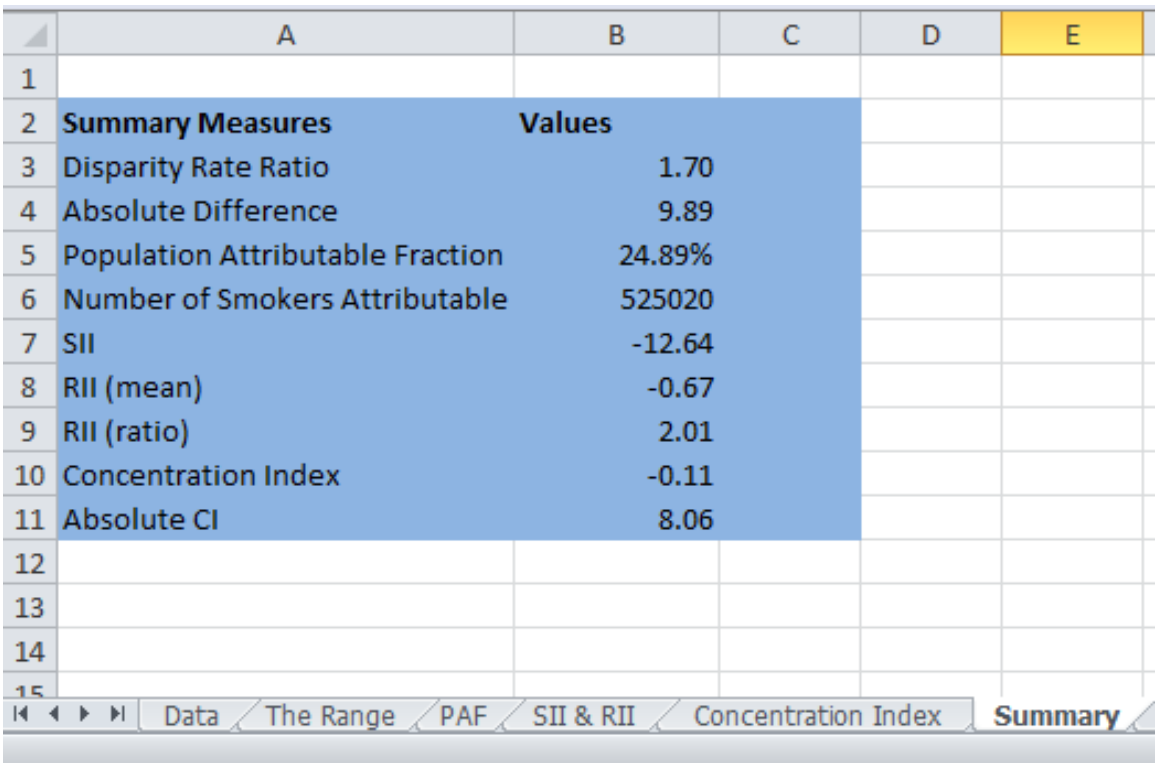
Following entry of the data, a bar graph will be produced demonstrating the rate of the health outcome by SES quintile and summary measures will be calculated under the different tabs. The Range tab calculates the disparity rate ratio and the absolute difference, the Population Attributable Fraction tab calculates the population attributable fraction and the total number attributable, the SII & RII tab calculates the SII, the RII_{mean} and the RII_{ratio}, and the Concentration Index tab calculates the concentration index and the percent redistribution. Graphical displays of the data are found on the SII & RII tab, displaying a scatter plot of the data with a linear trend line, as well as the Concentration Index tab, displaying the health concentration curve as well as the line of equality. The Summary tab displays all summary measures calculated.

Figure B2: Concentration Index Tab, Ontario 2009–10 by QAIPPE



QAIPPE	Pop	Smoking Rate/100	percent p	cumul % pop	No. Smokers	rel % Smoker	Concentra	Conc. Inde	Line of Equality
				0			0		0
1	2,195,932	24.01	0.19629	0.19628913	52726.2615	0.25054395	0.25054	-0.00455	0.19629
2	2,089,184	21.68	0.18675	0.3830363	45289.664	0.21520683	0.46575	-0.01749	0.38304
3	2,262,390	18.63	0.20223	0.58526595	42141.4331	0.2002471	0.666	-0.03307	0.58527
4	2,286,798	16.21	0.20441	0.78967738	37060.5994	0.17610407	0.8421	-0.05242	0.78968
5	2,352,928	14.12	0.21032	1.000	33229.1952	0.15789805	1	0	1
Total	11,187,232	159.1			210447.153				
							SUM	-0.10753	
Concentration	-0.107527	A negative concentration Index reflects a higher rate of smoking in lower income quintiles (Keppel,2005)							
Absolute CI	8.064507	The percentage redistribution needed from the advantaged half to the least advantaged in order for inequality to be equal to zero (Koolman and Van Doorslaer, 2004)							

Figure B3: Summary Data Tab, Ontario 2009–10 by QAIPPE



Summary Measures	Values
Disparity Rate Ratio	1.70
Absolute Difference	9.89
Population Attributable Fraction	24.89%
Number of Smokers Attributable	525020
SII	-12.64
RII (mean)	-0.67
RII (ratio)	2.01
Concentration Index	-0.11
Absolute CI	8.06

Appendix C: Working Application Results – Demographic Profiles

Tables C4: Demographic Characteristics of SES Measures in Ontario, 2009–10

Tables C4-A: Individual Household Income Quintile

Individual Household Income Quintile	Q1 Least Advantaged	Q2	Q3	Q4	Q5 Most Advantaged	Not Stated	Average
Population Proportion (%)	16	16	15	16	17	19	100 (Overall)
Age (Average)	44	45	43	42	44	43	44
Sex-Male (%)	43	47	50	53	55	46	49
Ethnicity-White (%)	57	67	79	85	90	59	72
Immigrant (%)	47	40	29	22	18	33	31
Married (%)	40	52	54	57	65	44	52
Urban (%)	90	87	83	82	71	82	82
Post-secondary (%)	50	57	64	71	80	46	61

Tables C4-B: QAIPPE

QAIPPE	Q1 Least Advantaged	Q2	Q3	Q4	Q5 Most Advantaged	Not Stated	Average
Population Proportion (%)	20	19	20	20	21	0.2	100 (Overall)
Age (Average)	43	43	44	44	45	36	44
Sex-Male (%)	47	49	49	49	51	47	49
Ethnicity-White (%)	59	69	72	78	83	51	72
Immigrant (%)	42	32	32	29	23	50	31
Married (%)	42	48	53	56	59	40	52
Urban (%)	90	87	78	79	79	62	82
Post- secondary (%)	55	58	61	62	68	87	61

Tables C4-C: ON-Marg Material Deprivation Quintiles

ON-Marg Material Deprivation Quintiles	Q1 Least Advantaged	Q2	Q3	Q4	Q5 Most Advantaged	Not Stated	Average
Population Proportion (%)	14	17	20	23	25	0.8	100 (Overall)
Age (Average)	43	44	44	44	43	42	44
Sex-Male (%)	48	49	49	48	51	46	49
Ethnicity-White (%)	62	68	74	75	77	73	72
Immigrant (%)	38	34	31	29	29	31	31
Married (%)	41	49	52	55	57	51	52
Urban (%)	90	84	77	79	86	52	82
Post-secondary (%)	51	58	60	62	69	68	61

Tables C4-D: ON-Marg Residential Instability Quintiles

ON-Marg Residential Instability Quintiles	Q1 Least Advantaged	Q2	Q3	Q4	Q5 Most Advantaged	Not Stated	Average
Population Proportion (%)	19	18	16	20	26	0.8	100 (Overall)
Age (Average)	45	44	45	44	42	42	44
Sex-Male (%)	47	49	49	51	49	46	49
Ethnicity-White (%)	67	70	80	77	69	73	72
Immigrant (%)	36	32	27	27	34	31	31
Married (%)	35	49	55	58	59	51	52
Urban (%)	98	93	76	70	79	53	82
Post-secondary (%)	64	59	59	61	61	68	61

Appendix D: Working Application Results – Smoking Rates by SES group

Table D5: Rates of smoking by socioeconomic group and by public health unit, 2009–10

Table D5-A: Smoking Rates by Individual Household Income Quintile

Smoking Rates by Individual Household Income Quintile	Q1% (95% CI)	Q2% (95% CI)	Q3% (95% CI)	Q4% (95% CI)	Q5% (95% CI)
PHU A, Large urban/rural mix	28.9 (20.5 – 37.3)	27.9 (19.2 – 36.6)	21.1 (13.6 – 28.6)	20.3 (13.8 – 26.8)	7.5 (3.7 – 11.2)
PHU B, Sparsely populated urban/rural mix	**	34.2 (15.0 – 53.4)	**	23.7 (9.2 – 38.1)	**
PHU C, Small urban/rural mix	31.3 (22.6 – 39.9)	17.0 (9.1 – 24.8)	15.4 (7.5 – 23.3)	13.2 (5.5 – 21.0)	13.4 (5.1 – 21.7)
PHU D, Large metro centre	14.5 (11.0 – 18.0)	20.6 (15.7 – 25.6)	22.3 (16.6 – 27.9)	16.5 (10.0 – 23.0)	10.1 (6.7 – 13.5)
Ontario	**25.4 (23.6 – 27.2)**	**19.2 (17. 6 – 20.8)**	**20.3 (18.5 – 22.1)**	**17.7 (16.0 – 19.4)**	**14.0 (12.8 – 15.1)**

Table D5-B: Smoking Rates by QAIPPE

Smoking Rates by QAIPPE	Q1% (95% CI)	Q2% (95% CI)	Q3% (95% CI)	Q4% (95% CI)	Q5% (95% CI)
PHU A, Large urban/rural mix	38.4 (28.8 – 48.0)	26.3 (18.3 – 34.3)	12.7 (7.8 – 17.6)	16.4 (8.8 – 24.0)	6.7 (4.0 – 9.3)
PHU B, Sparsely populated urban/rural mix	21.4 (11.2 – 31.6)	**	**	**	21.2 (10.9 – 31.6)
PHU C, Small urban/rural mix	23.8 (14.4 – 33.2)	23.7 (12.7 – 34.8)	19.4 (12.0 – 26.8)	**	9.6 (3.8 – 15.4)
PHU D, Large metro centre	16.1 (12.8 – 19.3)	18.25 (13.8 – 22.7)	17.6 (11.3 – 23.9)	17.4 (12.7 – 22.2)	10.3 (7.3 – 13.4)
Ontario	**24.0 (22.3 – 25.7)**	**21.7 (20.0 – 23.3)**	**18.6 (17.0 – 20.2)**	**16.2 (14.8 – 17.6)**	**14.1 (12.7 – 15.5)**

Table D5-C: Smoking Rates by ON-Marg Material Deprivation Quintile

Smoking Rates by ON-Marg Material Deprivation Quintile	Q1% (95% CI)	Q2% (95% CI)	Q3% (95% CI)	Q4% (95% CI)	Q5% (95% CI)
PHU A, Large urban/rural mix	46.6 (36.1 – 57.0)	27.9 (19.3 – 36.6)	19.8 (12.0 – 27.7)	10.7 (6.5 – 14.9)	10.1 (5.3 – 15.0)
PHU B, Sparsely populated urban/rural mix	24.1 (11.9 – 36.3)	19.9 (9.9 – 29.9)	**	-	20.0 (7.7 – 32.3)
PHU C, Small urban/rural mix	22.6 (15.9 – 29.2)	20.9 (11.3 – 30.5)	27.5 (16.0 – 39.0)	16. 7 (6.5 – 26.9)	11.6 (7.0 – 16.3)
PHU D, Large metro centre	17.1 (13.0 – 21.2)	18.2 (14.0 – 22.5)	15.4 (11.4 – 19.4)	15.2 (10.3 – 20.0)	11.7 (7.4 – 16.0)
Ontario	**25.5 (23.4 – 27.5)**	**22.2 (20.6 – 23.9)**	**19.0 (17.5 – 20.4)**	**16.3 (14.9 – 17.8)**	**14.9 (13.5 – 16.4)**

Table D5-D: Smoking Rates by ON-Marg Residential Instability

Smoking Rates by ON-Marg Residential Instability	Q1% (95% CI)	Q2% (95% CI)	Q3% (95% CI)	Q4% (95% CI)	Q5% (95% CI)
PHU A, Large urban/rural mix	30.1 (21.4 – 38.9)	23.2 (15.9 – 30.5)	19.8 (10.2 – 29.4)	11.8 (6.6 – 17.0)	14.1 (7.9 – 20.3)
PHU B, Sparsely populated urban/rural mix	**	34.5 (14.2 – 54.7)	16.2 (8.1 – 24.4)	**	18.7 (6.9 – 30.5)
PHU C, Small urban/rural mix	24.6 (15.7 – 33.5)	17.3 (6.2 – 28.4)	15.6 (7.3 – 23.9)	15.0 (8.1 – 22.0)	16.3 (7.2 – 25.3)
PHU D, Large metro centre	18.3 (14.7 – 21.9)	15.7 (12.2 – 19.1)	16.5 (11.0 – 21.9)	14.0 (9.1 – 18.9)	8.2 (4.1 – 12.2)
Ontario	**22.8 (20.8 – 24.8)**	**21.3 (19.7 – 22.8)**	**19.5 (17.9 – 21.0)**	**18.0 (16.5 – 19.5)**	**14.5 (13.2 – 15.8)**

Q1 represents the most advantaged quintile, Q5 represents the least advantaged quintile light green shading indicates high sampling variability CV (16.6-33.3),
** data suppressed due to extreme sampling variability (CV>33.3)

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