A recent report released by the Fraser Institute, “Obesity in Canada: Overstated Problems, Misguided Policy Solutions” makes numerous wide-reaching and controversial claims about the state of obesity in Canada.¹ In the first chapter of the report, analyses of national survey data from Statistics Canada are used to unequivocally conclude a lack of ‘negative or disconcerting trend’ in obesity and overweight. This conclusion is both surprising and intriguing as it goes against the scientific literature on Canadian weight trends.²⁻⁵ Closer examination, however, reveals a dismayingly large number of serious flaws in both the methods of analysis and scientific reasoning. This kind of quantitative but faulty analysis is misleading to readers who are not well versed in statistical methodology. The current commentary thus briefly examines three major issues in the Fraser report’s analysis of Canadian BMI prevalence time trends. It is hoped that this commentary will help guide public health professionals who need to interpret, or wish to perform their own, time trend analyses of BMI.

### ABSTRACT

The first chapter of the Fraser report “Obesity in Canada: Overstated Problems, Misguided Policy Solutions” presents a flawed and misleading analysis of BMI time trends. The objective of this commentary is to provide a tutorial on BMI time trend analysis through the examination of these flaws. Three issues are discussed:

1. Spotting regions of confidence interval overlap is a statistically flawed method of assessing trend; regression methods which measure the behaviour of the data as a whole are preferred.
2. Temporal stability in overweight (25≤BMI<30) prevalence must be interpreted in the context of the underlying population BMI distribution.
3. BMI is considered reliable for tracking population-level weight trends due to its high correlation with body fat percentage. BMI-defined obesity prevalence represents a conservative underestimate of the population at risk.

The findings of the Fraser report Chapter 1 are either refuted or substantially mitigated once the above issues are accounted for, and we do not find that the ‘Canadian situation largely lacks a disconcerting or negative trend’, as claimed. It is hoped that this commentary will help guide public health professionals who need to interpret, or wish to perform their own, time trend analyses of BMI.

### KEY WORDS: Body mass index; body weight; Canada; obesity; overweight; trends

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**Problems with the Fraser report Chapter 1: Pitfalls in BMI time trend analysis**

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**Revisiting the prevalence trend in overweight and obesity**

Figure 1 in the Fraser report shows the prevalence of overweight and obesity in Canadian adults of both sexes, estimated from self-report BMI from cycles 2003 to 2012 of the Canadian Community Health Survey (CCHS). These data are shown by the solid black circles in Figure 1 of this commentary. The mutual overlap in confidence intervals of prevalence estimates from 2008 to 2012 leads the authors of the report to conclude that there is “no statistically significant difference between the rates in 2008 and 2012”, providing proof presumably of the overall conclusion that weight trends are “stable or stabilizing” and that no “negative or disconcerting trend” exists.¹

This seemingly innocuous analysis is beset with serious errors. First, confidence interval overlap is an incorrect procedure for statistical comparison and can lead to false conclusions.⁶ For example, application of a two-sample z-test indicates a statistically significant (p≈0.01) difference between 2008 and 2012 prevalence estimates in spite of their overlapping confidence intervals.

Second, in ‘spotting’ regions of statistically similar prevalence, the authors have effectively performed multiple comparisons between all combinations of pairs of data values. While the confidence level (α) of a single pairwise comparison (correctly performed) is 95%, the α for multiple comparisons depends on

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the number of data points in the time series, their variances, as well as the number of points in the region of interest and its likely post hoc selection. The finding of no pairwise differences over the period 2008-2012 is thus associated with an unknown level of statistical significance.

Third, the frequency of pairwise statistical differences in prevalence is sensitive to temporal changes in survey sample size. As can be seen from Figure 1, the confidence intervals for the later years (2007-2012) are wider on average by a factor of $\approx 1.6$. This reflects the smaller sample sizes ($\approx 55,000$ adults) of the half-cycle CCHS estimates that were used over this period as compared with sample sizes ($\approx 116,000$ adults) of the full cycles of 2003 and 2005. As a result, there is an ipso facto increase in the likelihood of statistically similar estimates in this later time period that reflects a temporal change in sample size rather than a stabilization phenomenon. To demonstrate this, points in gray have been added to Figure 1 that represent the prevalence estimates from the full CCHS survey cycles 2007-2008, 2009-2010 and 2011-2012. Two sample z-tests show that once the sample sizes of all estimates are standardized, prevalence of overweight and obesity is seen to increase by a statistically significant amount every 4 years over the entire range from 2003 to 2012.

Fourth, the spacing of the two-year time intervals from 2003 to 2007 in all prevalence time trend plots of the Fraser Report, including Figure 1, were made equal to those of the one-year time intervals from 2007 to 2012, effectively compressing the $x$-axis between the years 2003 to 2007 and creating the visual illusion that trends are flatter in recent vs. previous years. The $x$-axis in Figure 1 in the current commentary correctly represents the two-year spacing between CCHS cycles 2003, 2005 and 2007, permitting an unbiased depiction of trends.

Pairwise comparison is in general not a reliable method to assess trends in time series as long sequences of data points may be statistically similar due to variability in individual measurements, even in the presence of a strong trend. Regression methods, in contrast, permit the statistically rigorous assessment of trend in all data points collectively, while accounting for their changing variance due to sample size. A straightforward linear regression fit to the original data using weights to account for the effect of the different sample sizes of the CCHS cycles results in a positive slope estimate of 0.37 that is statistically significant ($p<2\times10^{-6}$, $R^2=0.98$), indicating a continually increasing linear trend in the data. The fitted line (the dotted line in the current Figure 1) demonstrates goodness of fit. This increasing trend is maintained when the recent (2008-2012) data alone are fitted, where regression analysis yields a statistically similar slope value of 0.34 ($p<0.03$, $R^2=0.8$).

**Temporal stability in overweight prevalence hides a continuous change in the BMI distribution**

The prevalence of the overweight BMI category in Canadian adults has stayed approximately constant from 2003 to 2012.$^4$ These trends are presented, for sexes combined and separately, in Figures 2, 5 and 8 in the Fraser report as major arguments for the temporal stability of body weight in the Canadian population. This interpretation of overweight prevalence trends is both naïve and misleading as stability in overweight prevalence is in fact a consequence of a sustained and disquieting temporal change in the overall population BMI distribution.

To demonstrate this, we extracted the mean and percentiles of the BMI distribution for Canadian adults (both sexes combined) from the same CCHS cycles. It can be seen from Figures 2a and 2b that the mean and median (or 50th percentile) population BMI have been increasing since 2003, indicating a sustained rightward shift of the BMI distribution of the population toward higher values. This shift in distribution extends throughout the overweight range of BMI values, as shown by Figures 2c-2e which show the 60th, 70th and 80th percentiles plotted against time.

The reason that prevalence of the overweight category has paradoxically remained stable throughout this period is that the BMI distribution is widening as well as shifting. This phenomenon is illustrated in Figure 3, which shows the smoothed BMI distribution functions, estimated from the percentiles, for 2003 (black) and 2012 (gray). BMI is represented on the $x$-axis, and the vertical dotted lines span the overweight category; the areas under the distribution functions within this range are equal to the proportion or prevalence of overweight individuals in the respective populations. It can be seen that the
gain in population share of overweight individuals due to the rightward shift in distribution ‘A’ is offset by the widening of the distribution ‘B’ caused by the proportionate increase of obese individuals. Temporal stability in the prevalence of the overweight BMI category thus represents the continued redistribution of individuals away from the normal and into the obese categories of the BMI distribution.

Assessing the impact of BMI limitations on time trends

The inability of BMI to distinguish between fat and lean body mass is next described in the report, and this limitation is implied to refute mainstream analyses of BMI time trends, while supporting the conclusions of the chapter. Limitations exist for all health metrics, however, and they do not necessarily mean that a particular metric is unsuitable for an intended application. For example, due to its high correlation with direct measures of body fat percentage, BMI is recommended for monitoring population-level time trends of risk prevalence due to elevated body fat.

BMI-defined obesity has low sensitivity but high specificity for elevated body fat, which results in underestimation of the at-risk population. This is compounded by the substantial downward bias in self-report BMI, estimated to be ≈7-8% in the 2008 CCHS for adults aged 18-74, but whose magnitude is in general survey-specific. The upward shift in adiposity observed within the obese BMI category suggests further that estimates of the rate of temporal increase of the at-risk population may also be underestimated. Due to these principal limitations of BMI, CCHS obesity trends are thus a conservative representation of the growing levels of health risk due to weight gain in the Canadian population, which tends to further counter the conclusions of the chapter.

CONCLUSIONS

Three issues with regard to BMI time trend analysis drawn from Chapter 1 of the Fraser report have been discussed:

1. Spotting regions of confidence interval overlap is a statistically flawed method of assessing trend; regression methods, which have an unambiguous statistical interpretation, account for temporal change in sample size and measure the behaviour of the data as a whole, are preferred.
2. Temporal stability in overweight (25 ≤ BMI < 30) prevalence is in fact a consequence of a sustained change in the overall population BMI distribution.
3. BMI is considered reliable for tracking population-level weight trends due to its high correlation with body fat percentage. Obesity prevalence estimated from BMI represents conservative underestimates of the population at risk due to elevated body fat.

The results and interpretation of BMI time trend analyses can be markedly different if these issues are not accounted for. In particular, many of the findings in Chapter 1 of the Fraser report are either refuted or substantially mitigated. There are indications that the rate of increase in obesity prevalence is lower than it has been in the past, and there has been an intriguing downward fluctuation in the estimated 2012 prevalence for Canadian men. However, the existing data, under a more balanced and rigorous analysis, do not exhibit the unequivocal lack of ‘disconcerting or negative trend’, as claimed. More generally, it is hoped that this commentary will help guide public health professionals who need to interpret, or wish to perform their own, time trend analyses of BMI.
PITFALLS IN BMI TIME TREND ANALYSIS

RÉSUMÉ

Le premier chapitre du rapport Obesity in Canada: Overstated Problems, Misguided Policy Solutions de l’Institut Fraser présente une analyse imparfaite et trompeuse des tendances temporelles de l’IMC. En examinant ces imperfections, notre commentaire se veut un tutoriel sur l’analyse évolutive des tendances de l’IMC.

Trois problèmes sont abordés :

1. Repérer les zones de chevauchement des intervalles de confiance est une méthode statistiquement imparfaite d’évaluation des tendances; les méthodes de régression, qui mesurent le comportement des données dans l’ensemble, sont préférables.

2. La stabilité temporelle de la prévalence du surpoids (25 ≤ IMC < 30) doit être interprétée dans le contexte de la distribution sous-jacente de l’IMC dans la population.

3. Contrairement à ce que laisse entendre le rapport Fraser, l’IMC est jugé fiable pour suivre les tendances pondérales à l’échelle des populations en raison de sa corrélation élevée avec le pourcentage d’adiposité. La prévalence de l’obésité définie selon l’IMC représente même une sous-estimation prudente de la population à risque.

Les constatations du premier chapitre du rapport Fraser sont soit réfutées, soit considérablement atténuées lorsqu’on tient compte de ces problèmes, et l’allégation selon laquelle « la situation canadienne ne présente pas en général une tendance déconcertante ou négative » ne nous paraît pas fondée. Nous espérons que le présent commentaire pourra servir de guide aux professionnels de la santé publique qui ont besoin d’interpréter une analyse évolutive des tendances de l’IMC ou qui souhaitent effectuer leur propre analyse.

MOTS CLÉS : indice de masse corporelle; poids; Canada; obésité; surpoids; tendances