Review of the revised version of the *Draft California Communities Environmental Health Screening Tool* (July 30, 2012 Public Review Draft).

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Biography and Qualifications

Dr. John Bukowski is a senior associate at WordsWorld Consulting, a medical-communications consultancy located in Dayton, Ohio. John provides research assistance on epidemiology and public/occupational health, as well as general assistance on issues relating to clinical medicine. His epidemiology and public health career has spanned more than 24 years, including a broad base of experience within government, academia, and private industry. His clinical research experience includes a post as Director of the Clinical Research Centre at the University of Prince Edward Island, Canada. He has worked as a research scientist and epidemiologist for US EPA, NJ DEP, Merck, and ExxonMobil Biomedical Sciences, focusing on such varied topics as infectious disease and bioterrorism, children's health, worker health, air pollution, reproductive health, health effects of solvents, risk assessment, and emerging health issues. During his career, he has authored numerous peer-reviewed articles as well as a multitude of reports, critiques, reviews, and white papers. John has a Masters in Public Health from the University of Michigan and a PhD in epidemiology from the University of Medicine and Dentistry of New Jersey. He also holds a doctorate in veterinary medicine from Michigan State University. John is an emeritus editorial board member for the journal *Dose Response* (formerly *Nonlinearity in Biology, Toxicology, and Medicine*) and is an Adjunct Associate Professor in the School of Medicine at Wright State University.

Introduction

Based on a review of the July 30, 2012 draft revision of the cumulative impact (CI) screening tool (hereafter referred to as the CI tool), I find very little changes from the CI tool presented in the previous document entitled: "Cumulative Impacts, Building a Scientific Foundation", 12/31/10, Office of Environmental Hazard and Health Assessment (OEHHA). The major difference in the current document is the addition of a few more indicators, namely drinking-

water quality (under development) and pesticide use (exposure section), impaired water bodies (environmental section), and educational attainment (socioeconomic-status (SES) section). This latter indicator is somewhat misnamed in that it deals with percent dropping out of high school, not ultimate level of educational attainment. In this regard it is more an indicator of poverty/low income than it is of education. In some cases, environmental or exposure variables (eg, RTI releases and cleanup sites) have been weighted by the potential toxicity of involved chemicals, but this weighting does not appreciably change the ranking process.

The minor additions to the current document do not resolve the fundamental problems with the approach outlined in my earlier (9/17/2010) review (see attached). Nor does this revision address reliance on weak and subjective environmental-justice (EJ) epidemiology, the limitations of which were discussed at length in earlier reviews. Therefore, I will not reiterate those arguments and will confine my comments to two major limitations of the CI tool itself; namely, the utility of the chosen indicators and how they were combined to generate summary ranks.

Overriding Influence of Social Economic Status (SES)

By all appearances, this CI tool still consists of a hodgepodge of indicators chosen based on availability rather than science. Furthermore, many are highly correlated so that the same dimension is essentially counted more than once. This is especially true for the SES variables, which appear to drive the assessment through their correlations with most of the other indicators.

As I pointed out in my earlier review, SES is not a discrete risk factor or even a group of risk factors. Rather, it is an attempt to quantify or summarize underlying individual/population factors that affect health and wellbeing. To this end, SES is defined using surrogate measures representing various dimensions such as income, education, accumulated economic assets, occupation, social class, etc. (Braveman et al. 2001, Shavers 2007). Such measures must themselves be estimated using various surrogate variables that capture different characteristics of the dimensions being addressed. In fact, when speaking of reproductive outcomes, Berkowitz and Papiernik (1993) point out that

> "*Socioeconomic status, like race/ethnicity and marital status, is closely related to other demographic, behavioral, environmental, and medical factors that may influence pregnancy outcome and that cannot be easily controlled for in epidemiologic studies. Thus, socioeconomic status is presumably a proxy for these other factors rather than an independent determinant of preterm delivery.*"

To elaborate, established risk factors for adverse reproductive outcomes include maternal age, smoking, alcohol consumption, drug abuse, weight gain, marital status, race, prenatal care; birth order; gestational length; child's sex; small maternal prepregnancy weight; small maternal stature; complications of the current or previous pregnancy (eg, pregnancy-induced hypertension); maternal illness (eg, fever or untreated hypertension); stress; genetics; and job-related exertion (Bukowski 2004, Kramer 1987, 2003, Lang et al. 1996). Measures of SES such as education and race act primarily as surrogates for these disparate factors rather than as causal risk factors themselves. That is to say, low education (or another measure of low SES) in and of itself does not increase the risk of preterm birth, it is rather the poor diet, lack of prenatal care, smoking, and other factors associated with low education/SES that set up the relationship between adverse birth outcomes and this polyglot concept. This means that most of the impacts assigned to SES actually represent the effects of the underlying risk factors for which SES metrics act as proxies. It also means that it is virtually impossible to account for all these disparate risks just by including a few surrogates for SES, so that residual confounding is probable.

Because of its broad associations with both pollution and disease, SES represents a key factor within the screening tool. In fact, it can be shown that low SES and the underlying risk factors this includes drive the revised assessment via positive correlation with other components of the screening tool.

Close inspection of the CI tool shows that the screening components and their underlying indicators are not measuring independent constructs that are then combined. Rather, they appear to measure various aspects of the same construct through moderate to strong correlations to SES (see Figure 1). Exposures such as air pollution and traffic density are strongly correlated with

low SES (Gunier 2003, Tian 2012), and with each other given that vehicular traffic is the main driver of air pollution (Brauer 2003, Levy 2003). That is to say, people with low income or minority status tend to live in crowded urban centers with high traffic density that raises air-pollution levels. Similarly, people with lower incomes/opportunities tend to live in areas near factories, waste sites, or storage tanks because of cheaper rents and property values. Indeed, these are major contentions of the EJ literature.

Women of lower SES also tend to have more children than wealthier or more educated women (Huber 2010, Segal 1996). Therefore, SES should also have an influence on the sensitive-populations component by increasing the percentage of children less than 5 years of age in low SES neighborhoods.

SES should strongly influence the public-health component of the CI tool via direct impacts on disease, and also because of the nature of the public-health metrics chosen. In general, lower SES is associated with increased risk of diseases such as cancer, respiratory disease, heart disease, and poor reproductive outcomes (Banks 2006), although there are exceptions (eg, breast cancer is more common among women of higher SES). The impacts of risk factors related to SES (eg, smoking, diet, occupation, etc.), rather than pollution, are what drive these health effects. For example, Sir Richard Doll (1998) has shown that these myriad risk factors associated with low SES far outweigh the cancer burden associated with pollution.

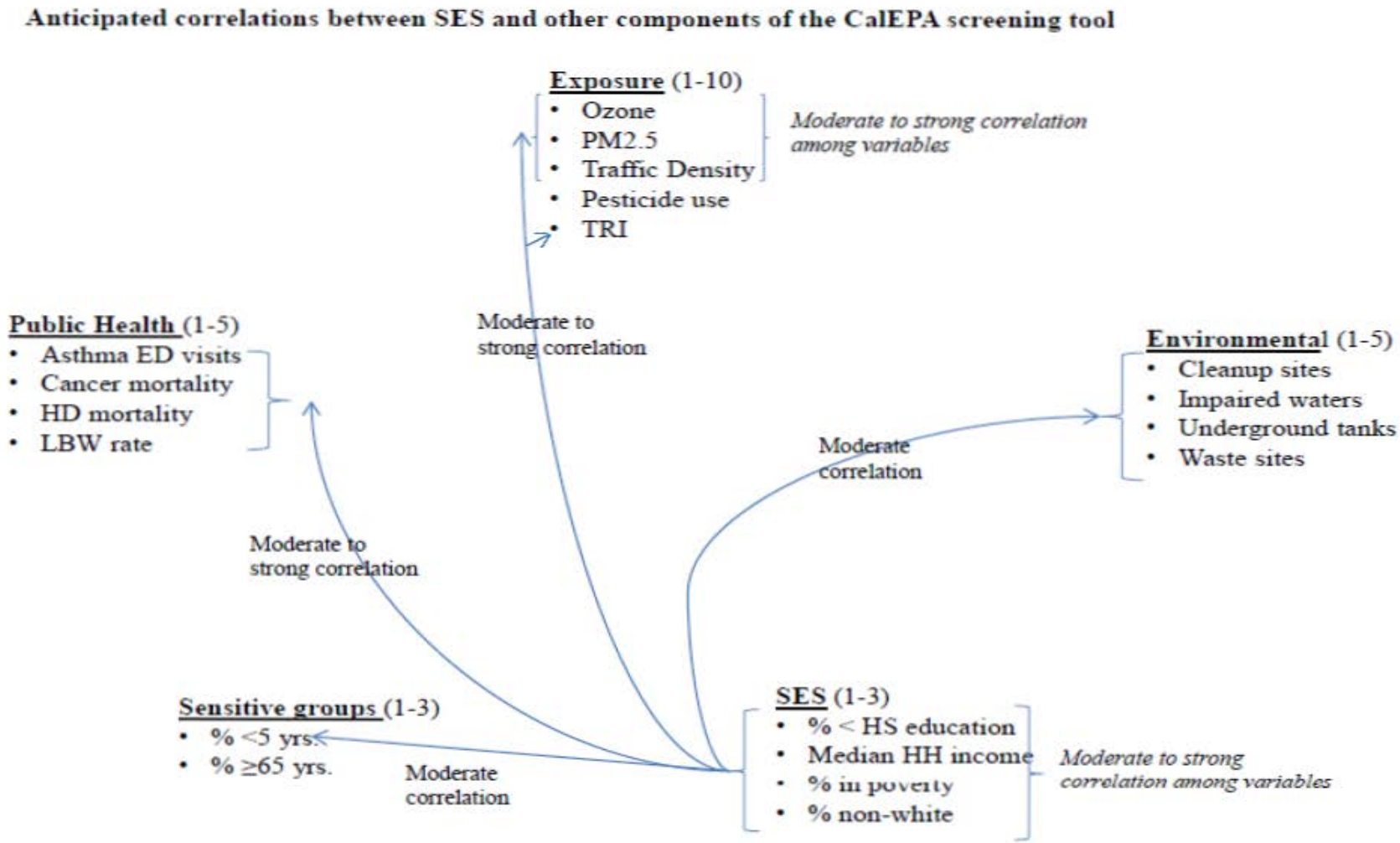

Figure 1. Graphic depiction of the overriding importance of SES on the CI tool, thereby making the other indicators somewhat redundant.

To make matters worse, the specific public-health metrics chosen by CalEPA actually increase the correlations with SES. For example, poor and minority people often lack health insurance, so they wait longer before seeking care and tend to use hospital emergency departments rather than primary care physicians. Therefore, relying on asthma emergency department visits (rather than doctor's visits or overall prevalence) as a public-health indicator intensifies any association with SES. Similarly, mortality rates encompass SES-related factors such as access to care, quality of care, diet, smoking, etc. Some of these variables increase the likelihood of disease (eg, smoking and poor diet), with others primarily affecting likelihood of death (eg, access to care and quality of care). Thus, focus on cancer and heart disease mortality applies a double dose of SES-related impacts.

The four SES metrics chosen by CalEPA also have a fairly high degree of correlation with each other. That is to say, people in poverty have low family income by definition, and also tend to drop out of school. Furthermore, all three of these metrics are much more common among minorities. In fact, this high level of correlation with race has created difficulties distinguishing among these measures. For example, Messers et al. (2010) were unable to statistically distinguish between race and other measures of SES within their data because of close correlations among these variables, thereby eliminating the heterogeneity across variables that is needed for analytical purposes. These authors noted that communities with a high proportion of minorities almost always fit within the lower SES categories, such that race and other economic measures captured the same information.

In conclusion, rather than dealing with different, independent aspects of risk as the authors intend, the various components of the CI tool largely address different aspects of low SES. The public-health component describes some of the health outcomes associated with low SES populations, the sensitive-populations component deals with their reproductive proclivities, and the exposure and environmental components address their geography, in which low-SES people live in crowded urban settings with factories, brownfields, and high traffic density. Therefore, the intricate CI tool developed by CalEPA probably adds little to a simpler approach based only on SES and (possibly) air pollution (given the large weight placed on that component). Indeed,

because of the strong intercorrelation among the SES indicators, a single SES variable such as median household income might capture much of the same information.

Limitations of the Cumulative Impact Score

The cumulative impact score is derived through a process of progressive ranking, averaging, and combining. Each indicator is assigned a percentile within the overall population; the multiple percentiles within each component are averaged; and then the ranks for exposure, environmental, and public health components are added together and multiplied by the sum of the sensitive population and SES components. However, there does not appear to be any scientific basis for the derivation of this process.

Statistical texts contain a variety of valid techniques for combining data within studies in order to generate meaningful summary statistics. Similarly, the discipline of decision analysis deals with the proper methods for selecting, weighting, and aggregating variables so as to reach scientifically valid decisions. Likewise, survey research has rules by which variables are scaled, ranked, and combined. However, the authors of the CI report provide no indication that they followed or even evaluated any of these various scientifically based techniques. Rather, the entire process seems to have been based on guess work. For example, no rational explanations are given for the choice of the scale ranges of 1-10, 1-5, and 1-3. Similarly, no reasonable explanation is provided for choosing which variables to add, or for multiplying the two sets of sums.

One is left to wonder what the cumulative-impact summary scores ultimately mean. The character of the input variables suggests that they represent only some vague estimate of "badness" based largely on SES and air pollution. But the precise nature of that badness cannot be determined unless one deconstructs the summary statistic hiding the inputs. In this regard, I strongly recommend that CalEPA/OEHHA make public the database of information used to derive each ranking, so that interested parties can review and understand the basis of the underlying assessment.

There are many unanswered/unanswerable questions associated with the CI tool, a few of which are listed below.

- Is exposure (scale 1-10) three times worse than low SES (scale 1-3) and twice as bad as poor environmental characteristics (scale 1-5)?
- Are the variables within a component equally bad, as suggested by their common scale?
    - That is to say, is an asthma emergency visit comparable to dying of cancer or heart disease?
    - Indeed, do variables such as pesticide application even represent exposure or linkage to some negative outcome?
- Do SES and sensitivity realistically multiply the "badness" of the other components?
- Perhaps most importantly, can the final ranking provide a reliable relative estimate of "badness?"
    - Is a score of 110 really worse than 109 or 108 or even 95?
    - Is a score of 100 seventeen percent better than a score of 120?

Any decision tool that cannot reliably answer these questions is itself questionable.

Conclusions

To the uninitiated reader, the screening tool appears to be a rigorous modeling approach that scientifically combines information from several disparate components. However, to the scientific community who are knowledgeable in the areas of risk assessment, decision analysis, and allied disciplines, this screening tool does not appear to be based on scientific principles supported by adequate documentation. Furthermore, the strong correlations among variables/components, along with the overriding importance of SES and (to a lesser degree) air pollution, suggest that this complicated screening process is unnecessarily complex for the information obtained, and that it probably adds little to an assessment of SES and air pollution alone. The summary nature of the impact scores hides this underlying deficiency.

The limitations discussed above are visible within the San Bernardino example provided in the CI document. A quick scan of the example tables (pp 63-64 of the CI document) shows that all four SES indicators are high, which is as expected given the high degree of correlation already mentioned. As might be similarly predicted, most of the other indicators are also high, including

both the sensitive-population (ie, prevalence of children) and public-health metrics. An exception is the pesticide-use indicator (17th percentile), which is negatively correlated with the other pollution indicators. That is to say, pesticide use is highest in less densely populated agricultural areas, which have lower traffic density and less air pollution. This single value lowers the exposure score slightly (from 8 to 7), but cannot have much of an impact given that it is averaged in with four high variables. The same reasoning applies to the single low value for impaired water bodies in the environmental component.

While the CI score probably distinguishes a highly polluted, low-SES community from an affluent one, such determinations can be made much more simply and transparently. Furthermore, it is not at all clear that the scale can reliably distinguish between less dramatic community differences.

The authors of the CalEPA report encourage the use of this CI tool in a variety of professional and lay settings, including decisions involving the distribution of scarce resources. Such decisions require setting decision cut points, below which resources are withheld. In such cases, interested stakeholders need to be assured that summary rankings truly reflect fine gradations in need or risk. That is to say, those who are five points below the resource cut point need strong assurance that they are at lower risk than those five points above. However, the non-scientific nature of the screening process makes it difficult to defend relatively slight differences in rank. It is likely that this would lead to litigation and considerable stakeholder distress

In conclusion, although the CI tool applied by CalEPA gives the appearance of technical rigor, it actually adds little information and obscures the impact of the underlying inputs. That being said, it would make more sense to increase transparency by simply ranking communities on SES and exposure, thereby allowing stakeholders to see the individual impacts of these indicators and to make decisions accordingly. Alternately, the CalEPA could contract with expert decision analysts that might be able to come up with a more scientifically defensible approach for these public health choices.

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