Enhancing the Chemical Mixture Methodology: Incorporating 20 Health Code Numbers

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Introduction

The Chemical Mixture Methodology (CMM) is used by the Department of Energy (DOE), its contractors, and other private and public organizations for emergency response planning and to assess the potential health impacts on individuals that would result from exposure to an airborne mixture of chemicals.

Hazard Indices (HIs)

The potential adverse health effects are estimated by summing the Hazard Indices (HIs) for each chemical present in the mixture. To calculate the HI for a given chemical, the concentration at a given receptor point is divided by the chemical's protective action criteria (PAC) value.

Health Code Numbers (HCNs)

Health Code Numbers (HCNs) are assigned to each chemical based on the human organs targeted by exposure. In the current CMM, only the top 10 HCNs ranked by severity are included in each CMM analysis. This project focuses on assessing what happens when doubling the potential number of HCNs for each chemical that could be used in each CMM analysis.

Methods

A total of 361 chemicals were used in testing (the entire CMM database contains over 3000 chemicals).

Rank	HCN	Target Organ Effect
1	17.00	Asphyxiants, anoxiants – acute effect
2	18.00	Explosive, flammable safety hazard (no adverse effects with good housekeeping)
3	13.00	Blood toxin, methemoglobinemia – acute effect
4	6.00	Cholinesterase toxin – acute effect
5	14.01	Eye irritant – severe
6	14.00	Severe irritant
7	15.01	Eye irritant- moderate
8	15.00	Moderate Irritant
9	4.01	Eye – acute, other than irritation
10	11.01	Respiratory irritant – acute severe or moderate but not mild irritant effects

Table 1. Health Code Numbers (HCNs) used to classify toxic effects by organ system. Only 10 out of 60 HCNs are listed.

A set of 127 representative mixtures were prepared for our analysis. Three different concentration distributions (called "ideal", "realistic", and "same") were used for each test mixture, providing a total of 381 test cases. For "ideal" concentrations, all chemicals in a mixture had the same HI. "Realistic" concentrations were derived using true-to-life chemical inventories from laboratory facilities. The "same" concentrations were defined by assuming each chemical in the mixture was present in the same concentration.

Results

To show the difference between the 10 HCN and 20 HCN approach, *Benefit* was calculated using the equation below, where "$\sum HI_{simple}$" is the simple sum of HIs and "$\sum HI_{HCN}$" is the maximum sum of HIs using the HCN approach.

$$Benefit\ (\%) = \frac{(\sum HI_{simple} - \sum HI_{HCN})}{\sum HI_{Simple}} \text{ x } 100$$

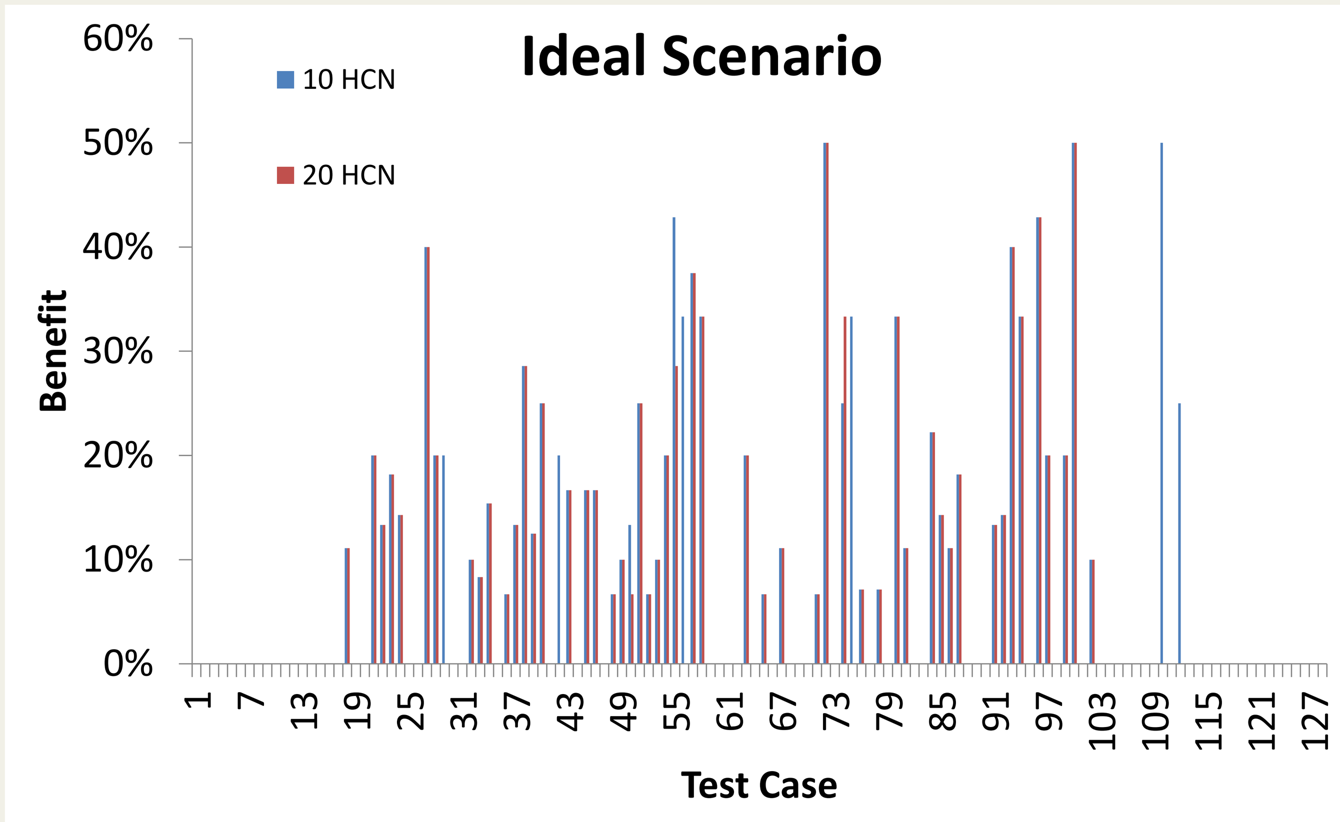

Figure 1. Benefit comparison (%) between the 10-HCN CMM and the 20-HCN CMM for the ideal test cases. Blank means no benefit was observed.

In 92% of the "ideal" test cases, the benefit was identical for both the 10-HCN and 20-HCN CMM. The average benefit for 10-HCN CMM was 27.4%, and the average benefit for 20-HCN CMM was 19.9%.

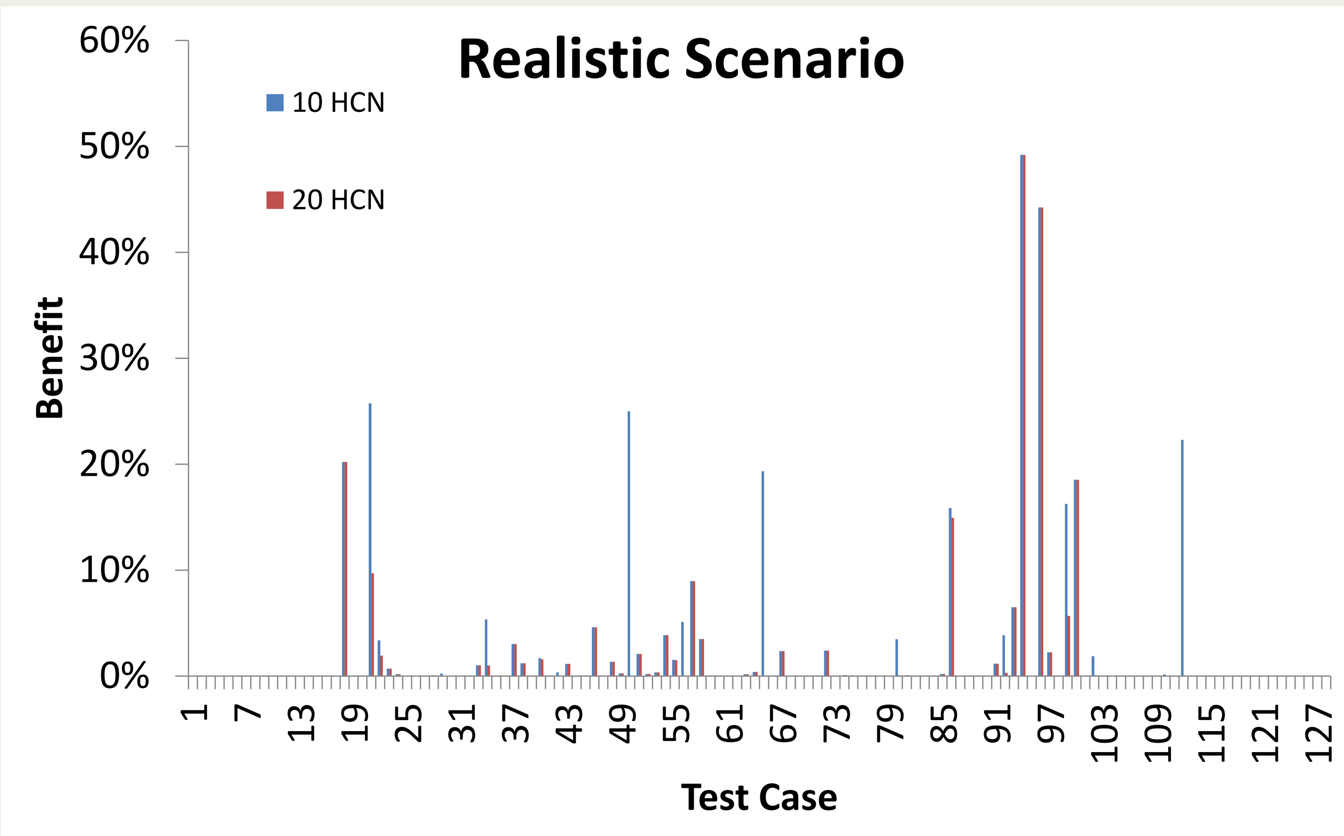

Figure 2. Benefit comparison (%) between the 10-HCN CMM and the 20-HCN CMM for the real test cases. Blank means no benefit was observed,

In 84% of the "realistic" test cases, the benefit was identical for both the 10-HCN and 20-HCN CMM. The average benefit for 10-HCN CMM was 11.4%, and the average benefit for 20-HCN CMM was 3.3%.

Results

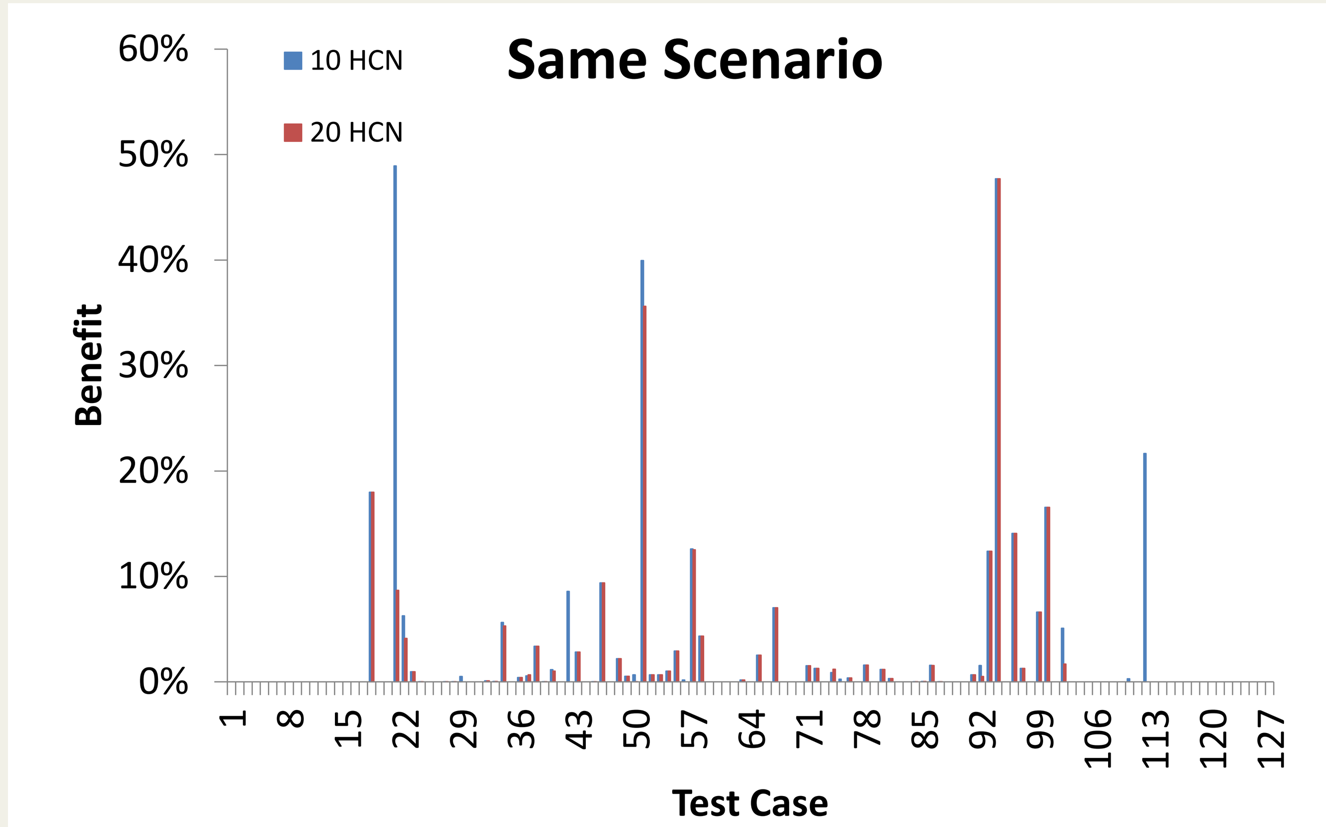

Figure 3. Benefit comparison (%) between the 10-HCN CMM and the 20-HCN CMM for the same test cases. Blank means no benefit was observed.

In 85% of the "same" test cases, the benefit was identical for both the 10-HCN and 20-HCN CMM. The average benefit for 10-HCN CMM was 8.2%, and the average benefit for the 20-HCN CMM was 6.1%.

Conclusions & Future Directions

CMM results were compared for all 361 test cases using both the 10-HCN approach and the 20-HCN approach. Only a slight difference was observed between the 10-HCN and 20-HCN approaches. This slight difference suggests that the top 10-HCNs give good representation of the potential toxic health effects. This also indicates that it is impractical to incorporate the 20-HCN approach in a future version of the CMM. Therefore, effort should be directed to other aspects of the CMM development such as refining the nervous system effects or respiratory irritant effects in the near future.

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