Chemical Mixture Methodology (CMM): Using 15 Health Code Numbers

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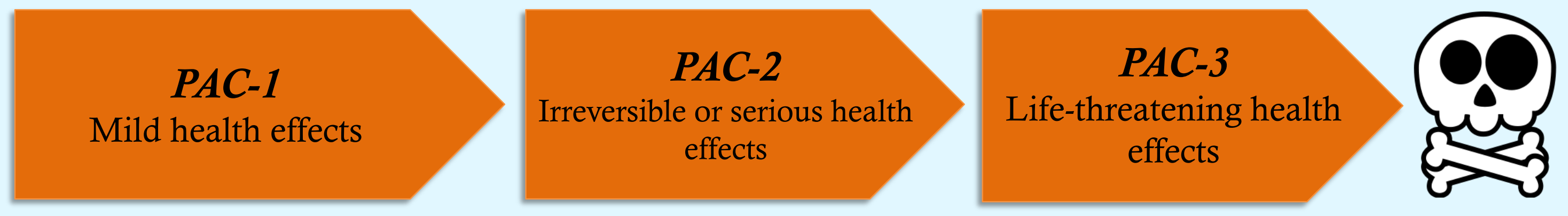
Introduction

Chemical Mixture Methodology (CMM) is the default DOE method used for an emergency response and safety planning for chemical mixtures with irreversible or serious health effects. There are three major components of CMM: ***Protective Action Criteria (PAC) values, Health Code Numbers (HCNs), and the Hazard Index (HI).***

Protective Action Criteria (PAC)

- Is the concentration limit for each chemical in its mixture; PAC-2 (usually in mg/m³) is recommended.



PAC-1
Mild health effects

PAC-2
Irreversible or serious health effects

PAC-3
Life-threatening health effects

Health Code Numbers (HCNs)

- Indicate the target biological systems or specific body organs that are affected by exposure to an individual chemical. They are ranked based on their seriousness and the impact of the health effect on a person's ability to take protective actions.

HCN	Rank	Target-Organ Effect
17	1	Asphyxiants, anoxiants--acute effect
18	2	Explosive, flammable safety (no adverse effects with good housekeeping)
13	3	Blood toxin, methemoglobinemia--acute effect
6	4	Cholinesterase toxin--acute effect
14.01	5	Eye irritant--severe
14	6	Severe irritant
15.01	7	Eye irritant--moderate
15	8	Moderate irritant
4.01	9	Eye--acute, other than irritation
11.01	10	Respiratory irritant--acute severe or moderate but not mild irritant effects
11.02	11	Respiratory irritant-acute moderate
14.02	12	Skin irritant--severe
15.02	13	Skin irritant--moderate
4	14	Systemic toxin--acute short-term high hazard effects
4.08	15	Heart, Cardiovascular system--acute effects

Table 1: The top 15 out of 60 HCNs ranked based on severity of target-organ effects to the human body.

Hazard Indices (HIs)

- Are calculated by using the concentration at a receptor point divided by the concentration limit or PAC value.

$$HI = Concentration\ /\ Limit$$

Methods

The CMM dataset consists of 3,000+ chemicals, in which up to 10 HCNs are listed for each chemical. This poster presents a study showing how the use of the top 15 HCNs rather than just the top 10 HCNs may affect CMM results. 361 chemicals from the CMM data set were provided with an enhanced set of HCNs. These chemicals are used in our 127 test mixtures. Each test mixture is examined using three different concentration scenarios: ***ideal, real, and same***, giving a total of 381 test cases. The ideal scenarios assign the same HI to each chemical, the real scenarios use actual laboratory data, and the same scenarios assign each chemical the same concentration.

The benefit of using an HCN-based approach over a non-HCN based approach is calculated using the following equation:

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

Comparing the benefit for the 15-HCN approach and the 10-HCN approach will indicate if the 15-HCN approach produces a substantial difference.

The Results

The benefit percentage comparison of the 15- and 10-HCN approaches are shown in following figures.

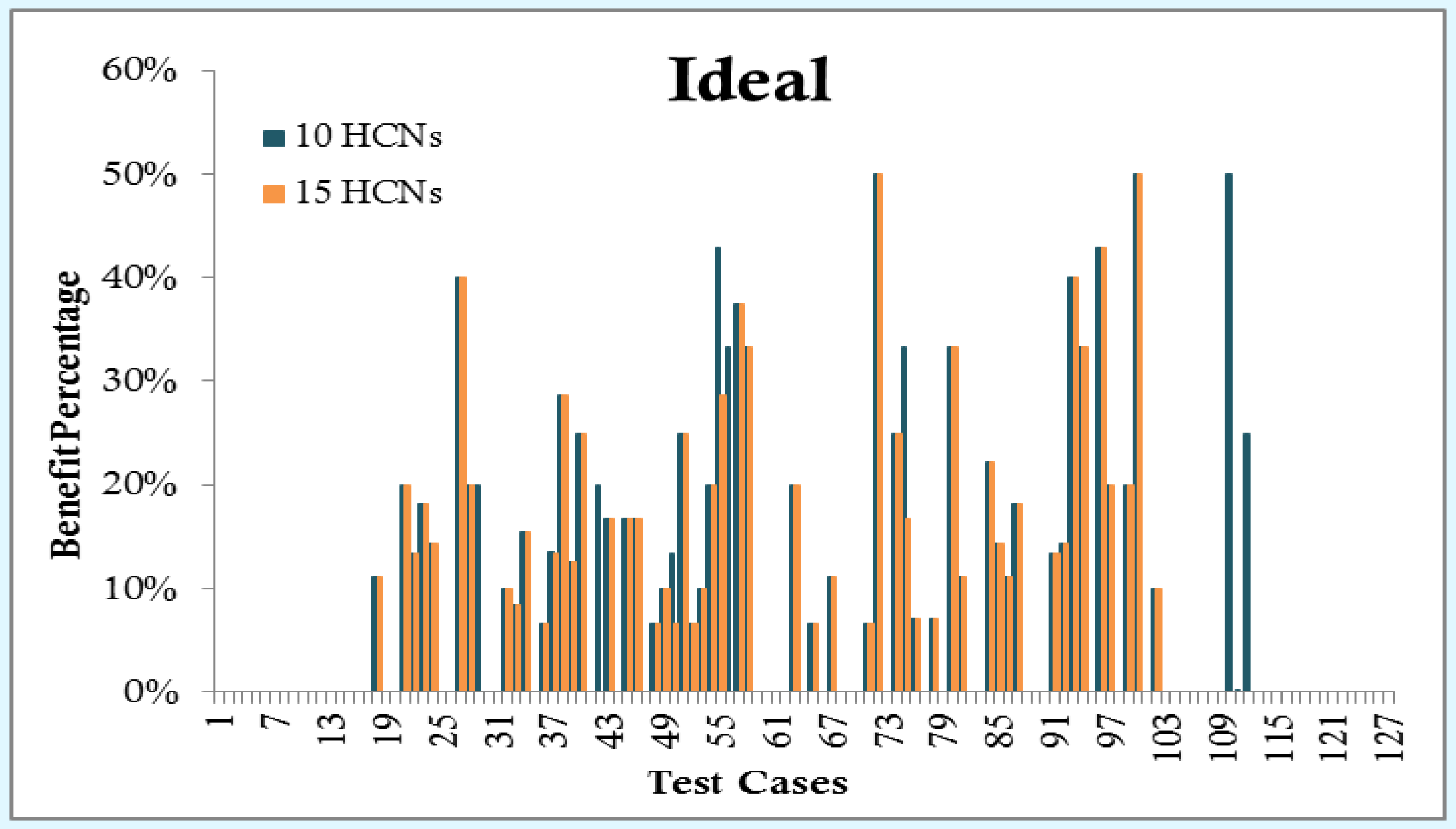


Figure 1: Ideal scenario test cases comparing the percent benefit using 10 HCNs vs 15 HCNs. The blank test cases show no percent benefit for either HCN scenario approach compared to the simple non-HCN approach. 91% of the ideal test cases were identical. The average benefit percentage of using the 10-HCN approach was 25.7%, while using the 15-HCN approach was 16.3%.

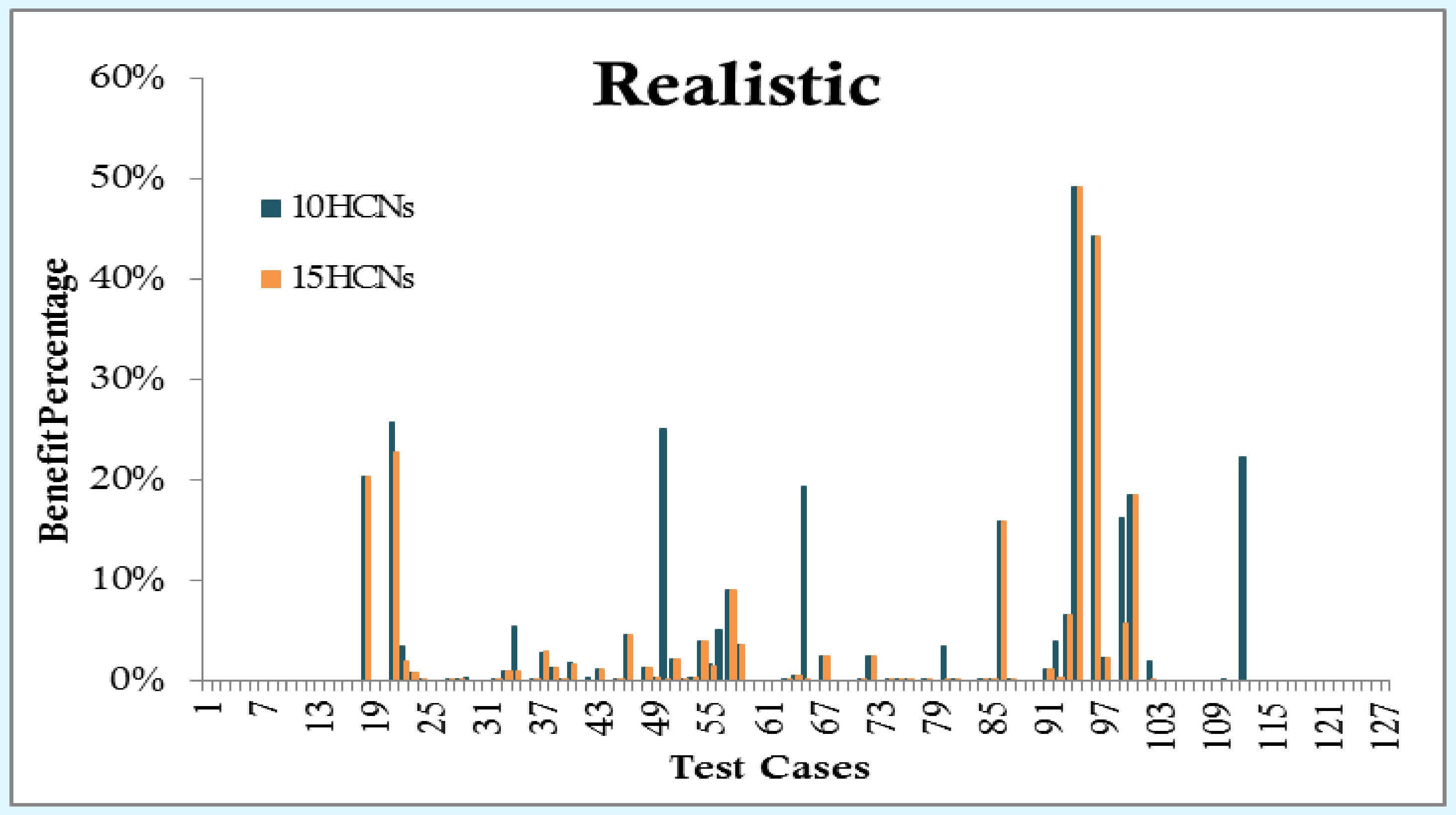


Figure 2: Realistic scenario test cases comparing the percent benefit using 10 HCNs vs 15 HCNs.

84% of the realistic test cases were identical. The average benefit percentage of using the 10-HCN approach was 6.9%, while using the 15-HCN approach was 2.7%.

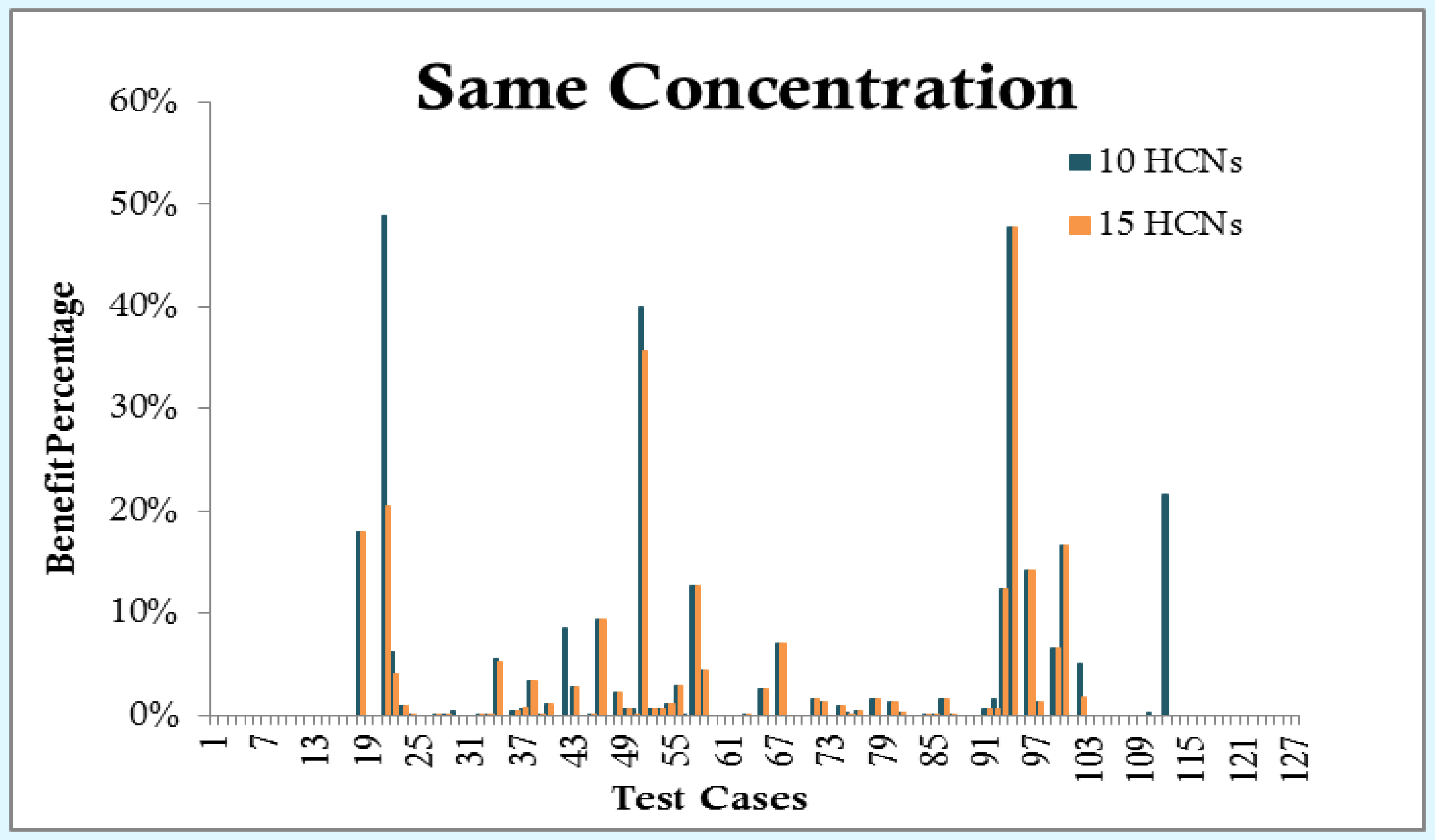


Figure 3: Same concentration scenario test cases comparing the percent benefit using 10 HCNs vs 15 HCNs.

87% of the same concentration test cases were identical. The average benefit percentage using the 10-HCN approach was 8.3%, while using the 15-HCN approach was 6.9%.

In the ideal concentration test cases, using the 10-HCN approach developed a 9.4% larger benefit percentage than using the 15-HCN approach. Within the realistic concentration scenario, there was a 4.2% larger benefit percentage of the 10-HCN approach compared to the 15-HCNs. Additionally, the same concentration test cases showed a 1.3% larger percent benefit using up to 10-HCNs compared to using up to 15-HCNs.

After analyzing the 381 test cases from ideal, real, and same concentration scenarios, the percent benefit of using the top 15 HCNs did not provide a substantial difference in comparison to using the top 10 HCNs. When incorporating the 15-HCN method, it produced a very small or equal change in benefit percentage as opposed to the 10-HCN method.

Conclusion

The addition of up to five additional HCNs for each chemical did not produce a substantial difference in the CMM results.

Using the 10-HCN approach to the CMM produced an overall larger benefit percentage than using the 15-HCN approach. Whether a test case is measured in an ideal, realistic, or same concentration scenario, it is safe to assume that using up to 10 HCNs is more useful for those who are exposed to a chemical mixture. This information suggests that it may not be necessary to include more HCNs in the CMM data set, and to continue assigning up to 10 HCNs for each chemical in the CMM data set.

The CMM team continues to update the CMM to support its many users in the United States and around the world. For further information on the CMM, visit http://orise.orau.gov/emi/scapa/chem-mixture-methodolgy/default.htm.

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