

Optimizing Physiological Monitoring for Distinguishing Exploration Medical Conditions

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Introduction: Clinically distinct pathological states can produce overlapping physiological manifestations, complicating diagnosis when access to comprehensive testing is limited. This challenge is amplified during long-duration exploration missions, where medical monitoring must operate under substantial resource constraints. We evaluated whether a reduced set of physiological measurements could preserve the qualitative condition-distinguishing information available across NASA's 119 Exploration Medical Conditions. **Methods:** A 119×35 condition-by-measurement matrix was constructed from published clinical and aerospace-medicine literature. In a conservative analysis, only direction-resolved physiological responses (increased, decreased, or normal) were permitted to distinguish condition pairs, while uncertain or nonspecific responses were excluded. Minimum test-cover and maximum-coverage mixed-integer linear optimization were used to identify the smallest measurement subsets preserving available pairwise distinctions, with independent combinatorial verification. **Results:** The complete 35-variable matrix supported 132 pairwise condition distinctions. Seven measurements: heart rate, blood pressure, respiratory rate, core temperature, CO₂/ventilation, audiometry, and visual acuity, formed the minimum set preserving all 132 distinctions. A four-measurement subset preserved 118/132 distinctions (89.4%), five measurements preserved 126/132 (95.5%), and six preserved 131/132 (99.2%). **Conclusions:** Most of the qualitative condition-distinguishing information available in the full physiological matrix could be preserved using a substantially reduced measurement set. These findings provide a quantitative framework for prioritizing physiological measurements in resource-constrained exploration medicine and support future optimization efforts that incorporate richer disease phenotypes and hardware constraints.