

The Army Health Hazard Assessment Program's Medical Cost-Avoidance Model

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Background: The Logistics Management Institute initially developed a medical cost-avoidance model (MCAM) to estimate the costs associated with the failure to eliminate or control health hazards of army materiel systems during 1997.

Methods: Presented is an updated version of the MCAM that uses cost factors for individual health hazard categories. The earlier MCAM calculated army materiel acquisition–life cycle medical costs based on a single cost factor for all hazard categories.

Results: The Army's Health Hazard Assessment (HHA) Program, which uses the MCAM while assessing 18 types of health hazards commonly found in materiel undergoing the acquisition process, recognized the need to refine the MCAM to be hazard-type specific. These hazard types have unique cost factors and serve as the basis for the revised model.

Conclusions: The revision will assist the HHA program in targeting health hazards that have the potential to affect soldier health and readiness.

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Introduction

A key to reducing health hazards associated with U.S. Army materiel is having the capability of demonstrating avoidable medical costs. The Medical Cost-Avoidance Model (MCAM; model) estimates avoidable acquisition–life cycle medical costs resulting from the elimination or control of health hazards by focusing on the medical cost factors that contribute to them. The type of hazard encountered and the level of risk drive the magnitude of each of the cost factors.

Health hazards are inherent to army materiel and may cause injury or illness at any point in the acquisition's life cycle. Treatment costs pose a considerable financial burden to military and veteran healthcare systems, and the resulting lost time degrades productivity and unit readi-

ness. Consequently, health hazard experts assess new or improved materiel by evaluating: types of hazards that exist; injuries or illnesses likely to result from the hazards; level of risk for each hazard; and, corrective actions needed to eliminate or control the hazards. The health hazard experts report this information to the materiel program managers responsible for the development and life cycle management of the materiel system.

The Health Hazard Assessment (HHA) Program Office, located at the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), Aberdeen Proving Ground, Maryland, centrally executes the army HHA program under the authority of Army Regulation (AR) 40-10.¹ Teams of medical subject matter experts, managed by HHA project managers, collectively perform health hazard assessments of materiel during all phases of the acquisition process. The experts initially address the health hazards during the concept phase with the intent of eliminating or controlling them earliest in the acquisition process. The goal is to resolve all of the health hazard issues during the program definition and risk-reduction phases.

The HHA process is also a Manpower and Personnel Integration (MANPRINT) domain (i.e., manpower, personnel, training, human factors, system safety, soldier survivability, health hazards) and addresses health hazard

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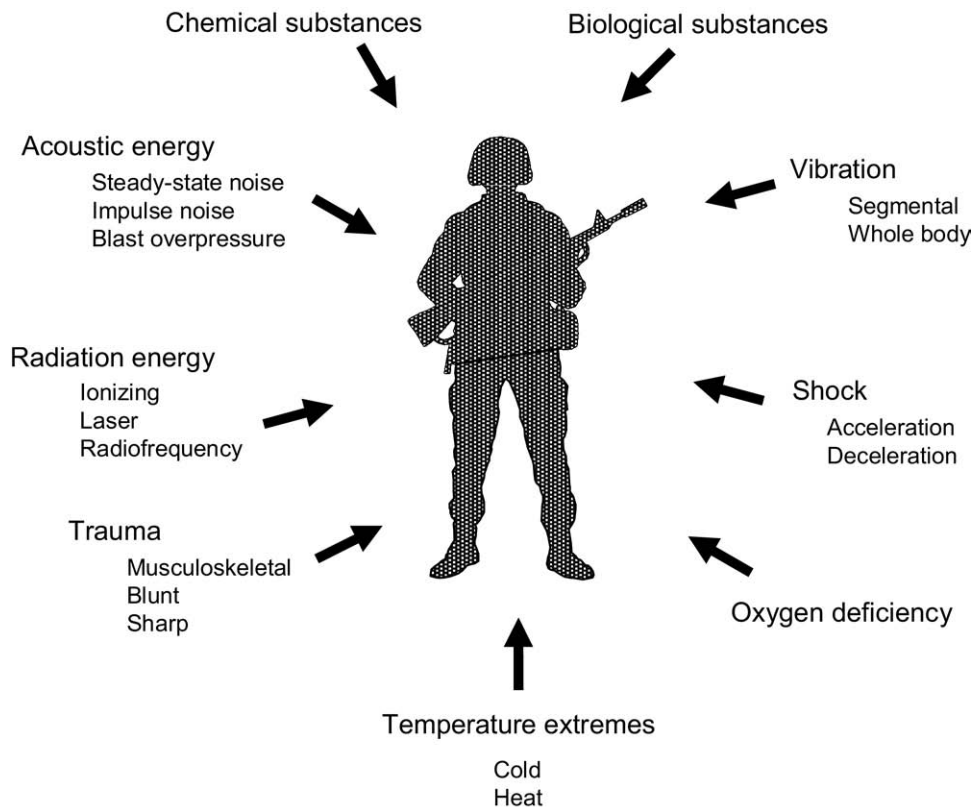


Figure 1. Eighteen types of health hazards assessed during the acquisition process

issues in support of numerous acquisition events (e.g., safety release, safety confirmation, type classification, milestone decision review, materiel release).

The primary objective of the HHA program is to provide recommendations to materiel and combat developers to eliminate or control the health hazards associated with the life cycle management of the following systems: weapon platforms, munitions, equipment, clothing, training devices, and other materiel systems.¹ The army's effort to eliminate health hazards from materiel systems links the HHA program with army war-fighting capabilities and performance. The materiel program manager or other acquisition-approving authority considers tradeoffs between the costs and benefits of health hazard elimination or control versus acceptance of the associated risk as part of the acquisition risk management process.

The initial model, described in earlier reports,^{2,3} calculated avoidable acquisition–life cycle medical costs based on a single cost factor for all hazard types. This meant, for example, that the MCAM medical cost calculation output for a radiation exposure hazard and a chemical exposure hazard of the same risk would have the same total medical costs. This single cost factor limitation was not well received, and it has been refined by the HHA program to be hazard-specific by assigning each of the 18 types of health hazards assessed during the acquisition process a unique cost factor

(Figure 1). This upgrade serves as the basis for the revised model and will assist the HHA program in targeting health hazards having the potential to affect soldier health and readiness.

Methods

Revised Model for Estimating Medical Costs

The key improvements of the revised model are detailed in the USACHPPM Technical Report for the Defense Safety Oversight Council (DSOC).⁴ These improvements include the ability to quantify hazard-specific costs and the ability to use estimated military health system direct-care medical costs (MHS Mart [M2] data),⁵ Military Personnel Cost data,⁶ Army Physical Disability Agency data,⁷ and Veterans Affairs (VA) Disability Compensation data.^{8–10} The model, which is based on the concept of hazard severity and hazard probability, presents the likely monetary impact of unabated medical and lost time costs.

The primary model utility is its ability to estimate total system-related medical and lost time costs. The materiel program manager can use this information to establish health hazard abatement priorities prior to materiel fielding, and to assess the potential impact on military readiness.

The individual outputs are valuable for understanding details of the potential medical costs resulting from exposure to a particular health hazard type and may present a direct correlation to military readiness. Lost-time injuries or illness resulting from exposure to the hazards associated with a system may result in extensive lost time on the job by affected soldiers. This statistic may be critical from a military readiness perspective. Soldiers away from the job decrease the readiness of their units. Additionally, extensive lost time may result in the need to acquire and train replacement personnel.

MCAM Framework

The framework for determining total medical costs (Figure 2) is based on five potential negative outcomes resulting from exposure to a health hazard. They include a visit to a military health system medical clinic for basic outpatient

treatment, medication, and tests [Clinic Costs]; a visit to a military health system hospital for inpatient observation, emergency or definitive treatment, and more detailed tests [Hospitalization Costs]; loss of time on the job due to clinic and hospital appointments, assignment to living quarters, and inability to perform on the job resulting in limited (temporarily restricted) duty [Lost Time Costs]; disability, either immediately while on active duty or at a later date after discharge or retirement [Disability Costs]; and fatality because of exposure severity or complications [Fatality Costs].

The model develops cost estimates using a number of data sources. It estimates medical and lost-time costs based on potential exposures to hazards. Estimates are based on health hazard types and expected medical outcomes from army medical data. Costs are derived from the following: M2 data; Military Personnel Cost data⁶; Army Physical Disability Agency data,⁷ and VA Disability Compensation data.^{8–10} These data sources are used to calculate cost factors such as incidence rates, average clinic costs, average daily hospital costs, and average salary costs. The MCAM application uses the cost factors and system information in algorithms developed to calculate costs.

Military medical care costs include estimated expenses associated with outpatient (ambulatory) care and hospitalization extracted from the M2 data. Lost-time costs include costs associated with absences from work for clinic visits (estimated),^{11–13} hospital stays (from M2 data), assignment to quarters (estimated), convalescent leave (estimated), and limited work/duty assignment (estimated). Military disability costs include costs for severance benefits, permanent and temporary disability while on active duty (from VA data), and VA disability compensation for those individuals who may have separated or retired from the military (estimated).

The USACHPPM DSOC Technical Report⁴ provides detailed formulas with the cost elements, and describes the details of the cost elements and their source.

MCAM Limitations

Limitations are also described in detail in the USACHPPM DSOC Technical Report⁴ and include the following: exclusion of purchased-care inpatient and outpatient claims

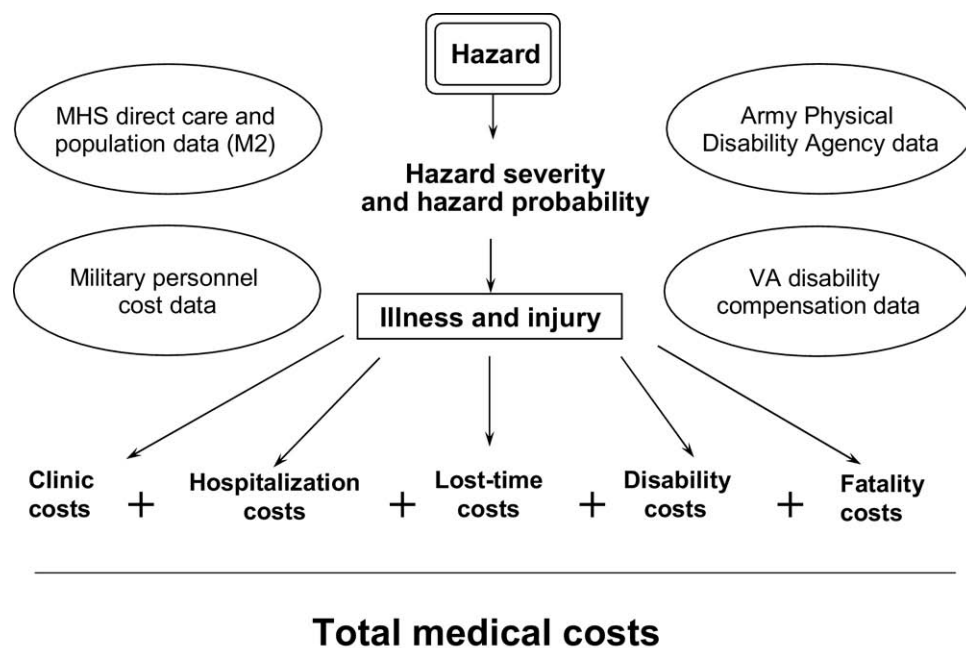


Figure 2. Framework for determining total medical costs
MHS, military health system; M2, MHS Mart

submitted by civilian providers; inability to calculate costs for specific military occupational specialties (e.g., 11B40, light weapons infantry); potential over-estimation of medical costs based on use of M2's estimated military health system full costs, which include potentially irrelevant fixed facility costs¹⁴; potential over-estimation of disability costs as a result of aggregate disability compensation data received from VA; estimation of how many personnel enter the VA disability system; and not accounting for the abatement costs associated with HHA recommendations (e.g., labeling, protective equipment, engineering redesign).

MCAM Assumptions

Assumptions are described in detail in the USACHPPM DSOC Technical Report⁴ and include the following: clinic visit duration^{15–18}; limited (temporarily restricted) duty assignment duration^{19–21}; assignment-to-quarters duration^{20,22}; convalescent leave duration^{17,19}; productivity reduction for individuals assigned to limited (temporarily restricted) duty^{21,23,24}; army proportion of VA population¹⁰; future diagnoses when calculating lost time and disability costs^{5,10}; M2 direct-care outpatient and inpatient clinical data aggregated to include the ancillary services (e.g., laboratory, radiology, pharmacy) associated with the visit^{5,14}; average fatality costs from an injury²⁵; and a general inflation rate derived from the Office of Management and Budget (OMB) discount rates.²⁶ Data sources were assumed to use accepted quality assurance/quality control procedures. Assumptions were made to provide quantitative data where no

historical military data existed or no explanation of actions taken was available, and many were made based on available literature. Reduction of these assumptions with actual military data would greatly improve the model.

MCAM Data Sources

Military Health System Direct Care and Population Data

Fiscal Year (FY) 2003 population, direct-care inpatient, and direct-care outpatient data for active duty army beneficiaries were extracted from the M2 data. The data elements used in the model from the M2 data⁵ are described in the USACHPPM DSOC Technical Report.⁴ Estimated pharmaceutical, radiology, and laboratory costs are captured in the direct-care outpatient and inpatient full-cost data elements used. Army retired/disabled population data were retrieved; however, the data were not used because there was no way of identifying this group within the aggregated population data.

Military Personnel Cost Data

The Army Military–Civilian Cost System (AMCOS) Lite database⁶ was used to determine fully burdened military personnel salary costs. The AMCOS is an automated tool that helps users estimate the costs associated with personnel. It contains a comprehensive database of personnel-related cost factors. Applications include life cycle estimation for weapon systems. Data were accessed from the AMCOS website on October 7, 2005. The USACHPPM DSOC Technical Report⁴ identifies specific populations^{26,27} and costs used for calculating salary and lost-time costs.

Army Physical Disability Agency Data

Available active duty disability data were retrieved from the USACHPPM Ergonomics Program (which obtained the database from the Army Physical Disability Agency in 1999).⁷ The database contained historical disability data decisions from approximately 1980 to 1999. Attempts to obtain current data were not successful; however, the database was considered adequate for the purpose of estimating active duty disability-related percentages for degree of disability and disposition category.^{28–31}

VA Disability Compensation Data

The VA disability data were obtained from the VA RCS 20-0227 report “Specific Diagnosis, Major Disability Compensation, Persian Gulf War” as of December 2003.⁸ This data contained the number of veterans receiving disability compensation by four digit Veterans Adminis-

tration Schedule for Disability Rating Disabilities (VASRD) code and degree of disability. VA compensation data³² were effective December 1, 2003.

Health Hazard Links

Each of the 18 health hazard types and their potential medical effects were linked with ICD-9 categories (three-digit)³³ and the VASRD Codes (four-digit)³⁴ medical outcome categories to estimate costs.⁴

Old Versus New Model Comparison

Example calculations were performed using the earlier model and the current model. The hazards were identified and the risks assigned by the health hazard assessors during their evaluation of an actual army materiel system. System X, the system evaluated, had an inventory of 7400, and each system had a crew of four soldiers.

Results

A comparison of System X medical costs using the earlier and improved versions of the model was performed. System X was evaluated by health hazard assessors and found to have ten hazards present (representing eight health hazard types): weapons combustion products, fire extinguishing agents, carbon dioxide, impulse noise, steady-state noise, cold stress, heat stress, oxygen deficiency (ventilation), non-ionizing radiation, and ionizing radiation. **Table 1** presents those hazards and the risk-assessment codes (RAC) assigned to each hazard based on definitions of hazard severity and hazard probability.¹ **Table 2** summarizes the life cycle costs (20 years) for the ten unabated health hazards associated with System X using the earlier and improved versions of the MCAM application.

Discussion

Model Comparison

The new model algorithms use military data while the old model uses a combination of military and industry data. The new model also details specific costs for each of the 18 health hazard types present while the old model displays the collective average of all nine health hazard categories present. The data used to populate the new model is incompatible with the old model based on different data sources and different algorithms. Additionally, an inflation factor has been incorporated into the new model, whereas the old model did not calculate life cycle inflated costs.

Table 1. Health hazards and associated risk indices for System X

Health hazard type	Hazard	Hazard severity	Hazard probability	Risk assessment code (RAC)
Chemical substances	Weapons combustion products	I	A	1
Chemical substances	Fire extinguishing agents	II	C	2
Chemical substances	Carbon dioxide	II	D	3
Impulse noise (acoustic energy)	Impulse noise	II	C	2
Steady-state (acoustic energy)	Steady-state noise	II	C	2
Cold (temperature extremes)	Cold stress	II	C	2
Heat (temperature extremes)	Heat stress	II	C	2
Oxygen deficiency	Oxygen deficiency (ventilation)	II	C	2
Laser (radiation energy)	Non-ionizing radiation	II	C	2
Ionizing (radiation energy)	Ionizing radiation	II	E	4

Old Model Summary

Incidence rates for the old model were estimated rates based on historical, industry-wide data. The output categories for the model included: clinic costs, hospitalization costs, lost-time costs, disability costs, rehabilitation costs, and death costs. The primary data sources used were the Army Medical Surveillance Monthly Report hospitalization data; U.S. Department of Labor, Bureau of Labor Statistics lost time data; and VA disability data. Clinic and hospitalization costs were determined based on Department of Defense (DoD) medical and dental reimbursement rates, and DoD Civilian Health and Medical Program of the Uniformed Services (CHAMPUS) Diagnostic Related Group (DRG) weights along with their respective length-of-stay factors.

Three industrial classifications (construction, transportation, and service) that were believed to represent the range of illness and injury rates within the army were selected. The incidence rates for these three classifications were used as risk surrogates (low, medium, and high). A USACHPPM panel of experts developed a consensus risk level for each of 15 army system categories. Incidence rates for illness and injury, hospitalization, lost time, and disability were developed using the sources described above.

The algorithms used in the old model were complex because the model used industry-wide incidence rates and calculated numerous illness, injury, hospitalization, lost time, and disability factors to quantify health hazard costs. It also used population distribution factors for hospitalization, lost time, and disability to account for the variability in medical outcomes and their associated costs.

The ICD-9 codes (medical outcome categories) were categorized under nine health hazard categories. In addition, the model combined the medical outcome categories

and calculated an average health hazard cost that was the same for every health hazard. While this would lose the specific hazard costs relating to specific medical outcome categories, we believed this approach was more feasible and would reduce error at the outset primarily because of the lack of actual military data.

New Model Summary

Estimated military medical expenses derived from FY 2003 M2 data, along with estimated disability costs from Army Physical Disability Agency data and Veterans Affairs Disability Compensation historical data, were used for the new model. The output categories for the model included: clinic costs, hospitalization costs, lost-time costs, disability costs, and fatality costs. A rehabilitation category was not used because of the inability to distinguish injury treatment cases from injury rehabilitation cases. Clinical data was considered as injury treatment to avoid potential duplication of costs. Furthermore, ICD-9 codes (medical outcome categories) were correlated to 18 health hazard types.⁴

The algorithms used in the new model were simpler than the algorithms in the old model because incidence rates and estimated medical costs were calculated using the military health system direct-care and population data.

The following conclusions have been reached regarding the new model:

- The MCAM produces reasonable “real world” results. The program applications of this model are representative of the basic outcomes that all prevention programs should measure.
- The MCAM outputs are reliable. Its parameters are measurable or can be estimated. Assuming health haz-

Table 2. Comparison of total life cycle (20-year) costs^{a,b} for the unabated health hazards of System X

Hazard	Model (\$)	Outpatient (\$)	Inpatient (\$)	Lost time (\$)	Fatality (\$)	Disability (\$)	Total (\$)
Weapons combustion products	New ^c	338,000	116,700	44,724,400	21,600	3,919,400	49,120,100
	Old ^c	88,400	81,900	27,900	4,000	99,600	301,800
Fire extinguishing agents	New	7,500	2,600	993,900	500	87,000	1,091,500
	Old	1,600	1,800	600	0	2,200	6,200
Carbon dioxide	New	400	100	49,700	0	4,400	54,600
	Old	100	100	0	0	0	200
Impulse noise	New	100	1,100	19,400	0	1,100	21,700
	Old	1,600	1,800	600	0	2,200	6,200
Steady-state noise	New	100	1,100	19,400	0	1,100	21,700
	Old	1,600	1,800	600	0	2,200	6,200
Cold stress	New	400	0	52,300	0	700	53,400
	Old	1,600	1,800	600	0	2,200	6,200
Heat stress	New	400	0	47,600	0	900	48,900
	Old	1,600	1,800	600	0	2,200	6,200
Oxygen deficiency (ventilation)	New	400	1,200	36,500	0	500	38,600
	Old	1,600	1,800	600	0	2,200	6,200
Non-ionizing radiation	New	100	0	9,700	0	200	10,000
	Old	1,600	1,800	600	0	2,200	6,200
Ionizing radiation	New	0	0	6,600	0	100	6,700
	Old	0	0	0	0	0	0

^aTable totals are rounded to the nearest hundred thousand.

^bFormulae for each cell may be found in reference 4, USACHPPM Technical Report for the Defense Safety Oversight Council (DSOC).

^cNew and old refer to model versions.

ard assessors perform risk assessments correctly and consistently, the model will produce the same outputs.

- The MCAM is adequate for use as a cost-estimating model. The model outputs are practical and help explain the RAC methodology used when assessing health hazards associated with a particular system.
- It is reasonable to expect minimal medical assessor variation in assigning RACs. Because of this concern, the model is most sensitive to the selection for hazard severity and hazard probability. Once the matrix cell has been selected using hazard severity and hazard probability, the model exhibits the greatest cost sensitivity in regards to health hazard type.⁴

All the algorithms are linear equations; therefore, costs are all proportional to the number of systems and the number of personnel per system once the risk has been determined. Depending on the health hazard type assessed, all cost categories (clinic costs, hospitalization costs, lost-time costs, disability costs, and fatality costs) will vary. In addition, lost-time costs can be several orders

of magnitude greater than the other costs and appear to represent a major factor in cost variation.

Other Applications for the Model

The MCAM, which was developed to assist the HHA process associated with army acquisitions, has potential for use when conducting other MANPRINT domain assessments in addition to HHAs. Soldier survivability personnel, system safety engineers, and human factors engineers may estimate medical costs for survivability, safety, and human factors hazards using a tailored version of the model application. Additionally, preventive medicine physicians, environmental science officers, sanitary engineers, and community health nurses may use the model when estimating medical outputs for occupational and environmental hazards found in training or on the battlefield, and, when determining specific military occupational specialty and overall medical and lost-time costs for specific disease and nonbattle injury ICD-9 codes.

Summary

This revised model provides reasonable cost estimates by quantifying estimated medical costs, obtained primarily from direct-care inpatient and outpatient records, for active duty army personnel that are likely to be associated with unabated materiel system health hazards. Quantifying health hazard costs improves the understanding of a stated health risk and assists system managers in making risk-management decisions. Additionally, quantifying health hazard costs improves the acquisition program manager's understanding of the monetary impact of not implementing HHA recommendations.

For example, a single engineering change may eliminate hazard costs across the entire fleet or equipment type. The benefit would be a reduction in lost time and other medical-related costs. Using the model concept for other preventive medicine programs is feasible and highly advantageous. Exposure to the causes of injury and disease can trigger a series of possible events: clinic visits, hospitalization, lost time, disability, and fatality. These outcomes are the same as the ones used in the model. A common bottom line for prevention programs is to reduce the personal, personnel, and supply of healthcare costs attributable to health hazards. These costs include clinic costs, hospitalization costs, lost time, disability, and fatality. To assess the reduction in medical costs, prevention programs can use the model outputs as performance indicators.

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