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Assessment of Model Outcomes Between the Integrated Medical Model (IMM) and the Medical Extensible Dynamic Probabilistic Risk Assessment Tool (MEDPRAT)

Matthew T. Prelich
Glenn Research Center, Cleveland, Ohio

Clara M. Gasiewski
Banner Quality Management Inc., Cleveland, Ohio

Lauren McIntyre
Glenn Research Center, Cleveland, Ohio

Binaifer Kadwa
Johnson Space Center, Houston, Texas

John Arellano
Aegis Aerospace, Inc., Houston, Texas

Jerry G. Myers, Jr.
Glenn Research Center, Cleveland, Ohio

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National Aeronautics and
Space Administration

Glenn Research Center
Cleveland, Ohio 44135

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NASA STI Program/Mail Stop 050
NASA Langley Research Center
Hampton, VA 23681-2199

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Matthew T. Prelich
National Aeronautics and Space Administration
Glenn Research Center
Cleveland, Ohio 44135

Clara M. Gasiewski
Banner Quality Management Inc.
Cleveland, Ohio 44135

Lauren McIntyre
National Aeronautics and Space Administration
Glenn Research Center
Cleveland, Ohio 44135

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National Aeronautics and Space Administration
Johnson Space Center
Houston, Texas 77058

John Arellano
Aegis Aerospace, Inc.
Houston, Texas 77058

Jerry G. Myers, Jr.
National Aeronautics and Space Administration
Glenn Research Center
Cleveland, Ohio 44135

Summary

The Medical Extensible Dynamic Probabilistic Risk Assessment Tool (MEDPRAT) is a computational model that provides human health and medical risk predictions for crewed spaceflight missions. MEDPRAT utilizes discrete event modeling and dynamic probabilistic simulation to predict critical mission outcomes (total medical events, crew health index, quality time lost, loss of crew life, removal to definitive care), condition occurrences, and resource consumption. Input parameters for MEDPRAT include crew attributes (e.g., sex), types of mission activities (e.g., whether and where crew members perform an extravehicular activity (EVA)), available resources, treatment information, and probability distributions for medical conditions. As an evolution of the Integrated Medical Model (IMM), MEDPRAT provides enhanced capabilities and higher fidelity, and incorporates more appropriate assumptions for long-duration spaceflight. IMM is the currently accepted standard for quantifying spaceflight mission medical risk in NASA operations that uses a probabilistic risk assessment (PRA) approach. MEDPRAT builds on the same logical foundation as IMM but implements the model

architecture through highly optimized Monte Carlo sampling methods. An analysis is performed comparing the outputs from IMM with those from MEDPRAT V1.0 and V2.0 for the same reference missions in order to quantify similarities and differences in the model outcomes. The juxtaposition between IMM and MEDPRAT V1.0 and 2.0 shown in this report demonstrates that these two models generate very similar results; where differences in outcomes are shown, these are in accordance with the underlying assumptions and differences in the model architectures. This validation effort further establishes the credibility and reliability of the MEDPRAT software.

Nomenclature

AS	alternate short stay
BoC	basis of comparison
CI	confidence interval
CAC	coronary artery calcium
CHI	crew health index
DRM	design reference mission
EMAC	Exploration Mission Analysis Cycle
EVA	extravehicular activity
EVAC	evacuation
FI	functional impairment
HLS	human landing system
HSRB	Human Systems Risk Board
HxAbSurg	history of abdominal surgery
iMED	Integrated Medical Evidence Database
IMM	Integrated Medical Model
ISS	International Space Station
LEO	low Earth orbit
LOCL	loss of crew life
MEDPRAT	Medical Extensible Dynamic Probabilistic Risk Assessment Tool
PoD	point of departure
PRA	probabilistic risk assessment
QTL	quality time lost
RTDC	removal to definitive care
SAS	space adaptation syndrome
SBO	small bowel obstruction
SR	service request
TME	total medical events
UTI	urinary tract infection
VIIP	visual impairment intracranial pressure

1.0 Introduction

1.1 Background and Motivation

The purpose of this Technical Memorandum is to report the validation analysis of the Medical Extensible Dynamic Probabilistic Risk Assessment Tool Versions 1.0.1 (MEDPRAT V1.0) and 2.0.0 (MEDPRAT V2.0) with the Integrated Medical Model (IMM) Version 4.1 (Refs. 1 and 2). This report

provides in-depth insight into the differences in model implementations and assumptions between IMM and MEDPRAT V1.0 and V2.0. Running the models with the same data/evidence and under identical initial and mission conditions enables the examination of differences in outcomes attributable to the models themselves.

MEDPRAT is a computational model developed in C++ that provides human health and medical risk predictions for crewed missions. MEDPRAT utilizes discrete event modeling and dynamic probabilistic simulation to predict critical outcomes of crewed spaceflight missions based on input parameters such as crew attributes, mission phase, available resources, treatment information, and probability distributions for medical conditions. The risk metrics associated with the critical outcomes include quality time lost (QTL) for the crew, probability of a loss of crew life (LOCL), probability of removal to definitive care (RTDC, formerly EVAC, representing the desire to evacuate), total medical events (TME), and the crew health index (CHI). Functional impairment (FI) is defined as a metric of (negative) crew performance on a scale of 0 to 1, where the higher the FI, the more deleterious the effects of the condition. QTL is defined in units of time and given as

$$\mathrm{QTL} = \mathrm{FI} \times \text{time impaired}$$

Hence, the QTL due to a condition is the product of the FI from that condition with the total time the condition affects the crew member at hand. The FI of a condition depends on whether a crew member encounters a best- or worst-case scenario (determined from a probability distribution) and whether the available resources are enough to treat said condition fully or partially or are unable to treat the condition. The CHI is defined on a scale of 0 to 1 for MEDPRAT (0 to 100 for IMM) and is given by

$$\mathrm{CHI} = 1 - \left(\mathrm{QTL} \div \left(\text{mission duration} \times \text{number of crew}\right)\right)$$

Attributes for crew members allow specific condition probabilities to be updated for those crew members with traits that may make them more susceptible to specific conditions. The crew attributes given as input parameters into IMM and MEDPRAT include sex (male or female), if crew member has dental crowns, if crew member wears contact lenses, if crew member has a coronary artery calcium (CAC) score higher than 0, and whether crew member has had abdominal surgery.

Three types of treatment paradigms are utilized. The fully treated paradigm signifies an unlimited availability of resources for treatment. The limited treatment paradigm signifies availability of only those resources specified in the medical set contents. The untreated paradigm signifies that no treatment is available on the mission, so no resources are being utilized at all.

In most cases, IMM is run with 100,000 trials; to reduce variability in the bootstrapped statistics, MEDPRAT is run with 300,000 trials (an input that can be set by the user). The only exception is scenario S–442 with IMM, which was executed with 300,000 trials as well.

1.2 Mission Segments Information

A major new functionality in MEDPRAT V2.0 that was unavailable in MEDPRAT V1.0 and IMM is support for mission segments in conditions and resources. A mission segment is a portion of mission time and/or a subset of the crew, enabling representation of multiple vehicles and environments during a single mission. Certain conditions affect astronauts with varying probability distributions dependent on the part (segment) of the mission being undergone (e.g., lunar extravehicular activity (EVA), lunar surface, Gateway, etc.); such distinctions between mission segments need to be accounted for in effective mission health probabilistic risk assessments (PRAs). The resource component of mission segments follows the same logic as the condition portion. Resources may be mapped to any segment and are available in the

specified quantity while the designated crew are in that segment, allowing for individual vehicles to have their own medical supplies tracked and optimized. Single-segment analyses are performed for IMM and MEDPRAT V1.0 comparisons given that IMM and MEDPRAT V1.0 have no concept of mission segments. A tool has been developed to convert from MEDPRAT V1.0 CSV input files to a MEDPRAT V2.0 XML input file to assist in a seamless integration between the two versions of MEDPRAT.

1.2.1 Segments Example

Suppose an Artemis-type lunar exploration mission consists of four crew members leaving Earth on day 0 and returning on day 24. They will travel in an Orion spacecraft, arriving at a Gateway station on day 5 and will not return to Orion until day 19. Two crew members will travel from Gateway in a human landing system (HLS) lander, landing on the Moon on day 8 and remaining on the Moon until day 16. Lunar EVAs will occur on days 9, 11, 13, and 14. Also on day 14, a crew member in lunar orbit will do an EVA. These EVAs would be canceled if any participant is more than 5 percent impaired.

Table I shows how this mission would be defined by segments with their respective segment duration and number of crew on each. LUNAR_EVA and DEEP_SPACE_EVA segments can be defined with EVA segment type and maximum function impairment of 5 percent. The EARTH_SAS and LUNAR_SAS segments can have the space adaptation syndrome (SAS) segment type. The ability to divide segments into subsegments is not supported for CSV, and crew members will need to be individually mapped to the appropriate segments.

In this example, suppose that evidence indicated differences in some SAS conditions, depending on entering microgravity from Earth as opposed to entering from the Moon. A pair of records can be coded, one tagged for each segment, EARTH_SAS and LUNAR_SAS. Likewise, suppose evidence indicated differences in some conditions depending on whether an EVA is conducted on the lunar surface as opposed to in deep space. Then, for each such condition, a pair of records can be coded, one tagged for each segment, LUNAR_EVA and DEEP_SPACE_EVA. The addition of this segments capability in MEDPRAT V2.0 enhances its flexibility and robustness in addressing diverse environments and mission scenarios.

TABLE I.—EXAMPLE OF LUNAR EXPLORATION MISSION DEFINED BY SEGMENTS WITH INTERVALS AND CREW MEMBERS

Segment name	Intervals	Crew
EARTH_SAS	0	All
ORION	0–5; 19–24	All
GATEWAY	5–8; 16–24	Crew1, Crew2
GATEWAY	5–19	Crew3, Crew4
HLS	8–16	Crew1, Crew2
LUNAR_EVA	9, 11, 13, 14	Crew1, Crew2
DEEP_SPACE_EVA	14	Crew3
LUNAR_SAS	16	Crew1, Crew2

1.3 IMM and MEDPRAT Model Assumptions and Differences

MEDPRAT evolved from IMM; it incorporates the main concepts and functionalities of IMM while also providing enhanced capabilities and a more computationally efficient architecture. As IMM is the currently accepted standard for quantifying spaceflight mission medical risk in NASA operations, a comparison between MEDPRAT and IMM is presented to aid the community in understanding the similarities and differences between the tools and, ultimately, in interpreting results from the two models. Many heuristics are imposed on both tools as a result of their dependency on the Integrated Medical Evidence Database (iMED) dataset (with the exception of MEDPRAT V2.0, which can be paired with iMED or NASA's Exploration Medical Capability Evidence Library (Ref. 3)), which largely dictates how the probabilistic condition data should be simulated and propagated. Although MEDPRAT incorporates many new capabilities, its basic functionality largely emulates that of IMM, particularly MEDPRAT V1.0, which produces results very similar to IMM. Due to its extended capabilities and differences in assumptions for non-low earth orbit (LEO) missions, MEDPRAT V2.0 is expected to yield slightly larger differences in the output results than IMM. Throughout this report, the authors will attempt to quantify the model similarities and differences.

Most of the observable differences between IMM and MEDPRAT V1.0 andV2.0 in the results stem from their respective implementation approaches and assumptions as cataloged in the following paragraphs. It is important to note that the effects of these assumptions can compound upon one another, and it is not always possible to differentiate which effect is dominating a change, particularly for small differences.

1. Both MEDPRAT and, to a certain extent, IMM simulate a mission through time in order to capture interactions between the crew, vehicle, resources, and conditions at any state at every point in time. The differences between the transient simulations of IMM and MEDPRAT lie in their allocation of resources, prioritization of simultaneous events, and reported metric outputs for LOCL and RTDC. The following assumptions will produce subtle differences in output:
   1.1 In IMM, when "per day" resources are prescribed for a condition, which may be modulated by the end of the mission, then the resources are all decremented or consumed instantaneously, whereas MEDPRAT will decrement them daily on a schedule. For example, if a crew member is supposed to take four ibuprofen capsules per day for 5 days to treat an ankle sprain, IMM will immediately decrement 20 capsules. In MEDPRAT, regardless of its version, four capsules will be decremented each day during the simulation. This means crew members may compete for available resources if they are using the same treatment and, should treatment be prescribed near the end of the mission, all resources may not be consumed because the mission will end before the treatment protocol ends. The resultant effect is that IMM is expected to report slightly higher resource consumption. However, in certain cases, and as a corollary to assumption 2, which follows, MEDPRAT V2.0 can report higher resource consumption because crew members contracting RTDC or LOCL remain in the mission and continue using resources, whereas they are effectively removed from the mission in IMM and MEDPRAT V1.0.
   1.2 If a condition occurrence is found to progress to both LOCL and EVAC/RTDC, IMM will report both a LOCL and RTDC; the start time that occurs first is considered the end of the mission for the crew member. MEDPRAT V1.0 will schedule the LOCL and RTDC, but only the one that occurs first during simulation will be reported in the output as it is assumed that EVAC/RTDC is removing an alive crew member who cannot then perish during simulation and that a crew member who has already perished will not be evacuated. In MEDPRAT V2.0, as documented in assumption 2, an RTDC-flagged crew member remains in the simulation, which means that if RTDC occurs before LOCL in time, both the RTDC and the LOCL would be reported. MEDPRAT V2.0 reports only

LOCL if LOCL happens first, and reports both if RTDC happens first. The resultant effect is that for MEDPRAT V1.0, IMM is expected to report slightly higher EVAC/RTDC and significantly higher LOCL, as EVAC/RTDC is often scheduled to occur sooner than LOCL. This effect is most observable in the untreated paradigm. The resultant effect for MEDPRAT V2.0 is that EVAC/RTDC and LOCL is higher than in MEDPRAT V1.0 and RTDC is higher than in IMM.

1.3 IMM, under the limited treatment paradigm, reports resource consumption desired by the crew regardless of the limited medical set actually available. This effectively makes the IMM-reported resource consumption in the limited treatment paradigm comparable to the fully treated resource consumption. MEDPRAT, under the limited treatment paradigm, is capped at the number of resources that are available in the medical set for the simulation. The resultant effect is that a fair comparison between resources is possible only for the fully treated paradigm.

1.4 When resource dosing is prescribed as "end of mission," IMM treats this data the same way as a per day resource is prescribed, where the resource is capped at a certain amount modulated by the remaining days in the mission. In MEDPRAT, end of mission resources are consumed at the given rate until the end of the mission with no cap. For example, consider a prescription of one acetaminophen capsule per day until end of mission. In IMM, this prescription may have a cap of 10. If the condition occurs 30 days before the end of the simulated mission, IMM will report that 10 capsules were consumed, and MEDPRAT will report 30. Conversely, if the condition occurs 5 days from the end of the mission, IMM and MEDPRAT will both report five capsules were consumed. The resultant effect is that MEDPRAT is expected to report higher consumption of end of mission prescribed resources.

2. In IMM and MEDPRAT V1.0, a crew member who is removed to definitive care (RTDC'd) is effectively removed from the mission; once RTDC'd, they experience no more conditions and consume no more resources. For MEDPRAT V2.0 to be more analogous to long-duration spaceflight, this assumption is modified. In MEDPRAT V2.0, should a condition occurrence be found to progress to RTDC, the RTDC is scheduled and reported, but the related crew member remains in the simulation. The crew member may experience additional conditions and consume resources and be eligible for LOCL or RTDC again. RTDC effectively represents the desire to evacuate. The resultant effect is that, in simulations run with MEDPRAT V2.0, condition occurrences may be higher, which therein can lead to higher resource consumption and higher LOCL and RTDC events (as a single crew member can be flagged for RTDC multiple times in MEDPRAT). This can even result in the average RTDC per mission exceeding the number of crew in the simulation.
3. All MEDPRAT simulations are run with 300,000 trials to ensure convergence of the simulation. As IMM is typically run with 100,000 trials, the full variability of rare events like LOCL may not be fully captured. Consequently, the differences in the occurrence of rare events like LOCL between IMM and MEDPRAT may reflect this aspect. The resultant effect is that very rare events may vary in their output results, particularly for LOCL.

Throughout the analyses presented in this report, the effects or assumptions mentioned previously are referenced by number, where appropriate, to identify which model implementation difference affects a specific comparison. This is not an exhaustive comparison; other metrics, such as number of trials in which a resource is depleted, are possible but are determined to be out of scope for this analysis.

1.4 Clarifications on Input Data

It is important to note that both IMM and MEDPRAT accept user-defined medical conditions and their associated parameters; hence, performance is directly related to the user input being specified.

Neither IMM nor MEDPRAT own or attempt to corroborate the veracity of any model input files or medical evidence. IMM is tailored to address specific types of data in iMED, whereas MEDPRAT is more adaptable to other input data formats, such as the Evidence Library. For this validation analysis, an instance of the iMED data is used to provide medical condition input to IMM and MEDPRAT; their predictions are compared to ensure they are within an acceptable error range from each other. Verification that the underlying mathematics are implemented correctly in MEDPRAT V1.0 and V2.0 occurs through nearly 200 built-in unit and regression tests. Refer to the MEDPRAT Testing Document CCMP-MEDPRAT–DOC–04 (Ref. 4) for more information.

Comparisons between the outputs from IMM and MEDPRAT V1.0 and MEDPRAT V2.0 for various design reference missions (DRMs) are performed as a means of demonstrating the similarities between the outputs and, where differences occur, the effect of the assumptions that lead to such differences in risk metrics. Qualitative descriptors such as slight, small, similar, etc., are used to highlight specific differences between the IMM and MEDPRAT V1.0 and2.0 outcomes. These terms are particularly employed when MEDPRAT V1.0 or V2.0 means fall within the IMM confidence interval (CI) or when forecasting an anticipated outcome rather than describing an observed one.

2.0 Methods

2.1 Input DRM Data

Comparisons are performed on eight separate potential real-world scenarios—also called service requests (SRs)—for lunar, International Space Station (ISS), and Mars missions, along with varying cases for each DRM within a mission scenario. The simulations provide results for the fully treated (unlimited resources), the limited treatment (limited resources), and the untreated paradigm (no resources) for each DRM. These scenarios and DRMs are described in the following subsections.

2.1.1 S–386: Risk of Appendicitis and Cholecystitis Versus Risk of Small Bowel Obstruction (SBO) following Prophylactic Surgery

In all DRMs for S–386, a 2.5-year (913.125 days) Mars mission with six crew members is simulated (Table II). This is based on IMM SR S–20170710–386.

TABLE II.—SCENARIO S–386: RISK OF APPENDICITIS AND CHOLECYSTITIS VERSUS RISK OF SBO FOLLOWING PROPHYLACTIC SURGERY

DRM	Description	Mission length, days	EVA (if applicable)
1	Control, no crew has history of abdominal surgery (HxAbSurg) (risk of SBO = 0)	913.125	None
2	Appendectomy only, risk of appendicitis = 0, risk of SBO = 0.0016 events per person-year, best case = 75%, worst case = 25%, all crew have HxAbSurg, appendicitis condition removed	913.125	None
3	Cholecystectomy only, risk of cholecystitis = 0, risk of SBO = 0.0006 events per person-year, best case = 67%, worst case = 33%, all crew have HxAbSurg, acute cholecystitis removed	913.125	None
4	Appendectomy and cholecystectomy, risk of appendicitis and cholecystitis both 0, risk of SBO = 0.0016 to 0.0022 events per person-year, best case = 67%, worst case = 33%, all crew HxAbSurg, appendicitis/cholecystectomy removed, SBO incidence fixed at 0.0022	913.125	None

2.1.2 S–387: Impact of Sex on Medical Outcomes for Deep Space Missions

For evaluating medical risk outcomes due to the sex of crew members, 42-day lunar, 6-month (180 days) ISS, and 2.5-year Mars missions are simulated (Table III). This is based on IMM SR S–20141022–190—Sex Differences in Spaceflight.

2.1.3 S–388: Impact of Heroic Medical Care Measures on Subsequent Medical Outcomes

In all DRMs for S–388, a 540-day Mars mission with four crew members is simulated based on IMM 3.0 results from SR S–20160822-366 (Table IV). A resource-depleting event is an event where an ill crew member is treated for a severe illness, consequently depleting medical resources. Worst case treated urinary tract infection (UTI) and sepsis is the initial illness. The maximum quantity of resources used to treat the worst case of each of these conditions for a period of 72 hours is deducted from the baseline medical capability at the appropriate time point of each DRM run. Other EVA conditions are removed (paresthesias secondary to EVA, decompression sickness secondary to EVA, and fingernail delamination secondary to EVA).

2.1.4 S–412: Lunar 27.5-Day and 7.5-Day Assessment

For the S–412 DRMs, two Artemis 7.5-day missions with two crew members and a 27.5-day mission with four crew members are simulated (Table V). The first 7.5-day DRM uses an ISS medical set; the second 7.5-day DRM uses an optimized 5-lb set from the first DRM to run the same mission design. These correspond to IMM SR S–20190528-412.

2.1.5 S–435: ISS Probabilistic Risk Assessment Update

Scenario S–435 is a 6-month and six-crew ISS mission with three two-person EVAs at the quarter, half, and tri-quarter points in the mission (Table VI). Crew members 2 and 5 perform the EVAs.

TABLE III.—SCENARIO S–387: IMPACT OF SEX ON MEDICAL OUTCOMES FOR DEEP SPACE MISSIONS

DRM	Description	Mission length, days	EVA (if applicable)
1	Control, mixed crew of two males and two females	42	None
2	Control, mixed crew of two males and two females	180	None
3	Control, mixed crew of two males and two females	913.125	None
4	All female crew, four females	42	None
5	All female crew, four females	180	None
6	All female crew, four females	913.125	None
7	All male crew, four males	42	None
8	All male crew, four males	180	None
9	All male crew, four males	913.125	None

TABLE IV.—SCENARIO S–388: IMPACT OF HEROIC MEDICAL CARE MEASURES ON SUBSEQUENT MEDICAL OUTCOMES

DRM	Description	Mission length, days	EVA (if applicable)
1	Control, no initial resource-depleting event	540	None
2	Resource-depleting event on first day of mission	540	None
3	Resource-depleting event at end of first quarter of mission timeline (day 135)	540	None
4	Resource-depleting event at mid-mission (day 270)	540	None
5	Resource-depleting event at beginning of last quarter of mission (day 405)	540	None

TABLE V.—SCENARIO S–412: LUNAR 27.5-DAY AND 7.5-DAY ASSESSMENT

DRM	Description	Mission length, days	EVA (if applicable)
1	Using ISS medical set, removing space adaptation and unrelated conditions, two crew members	7.5	Days 2, 3, 5, 6
2	Using optimized 5-lb set from DRM number 1 to run the same 7.5-day mission, two crew members	7.5	Days 2, 3, 5, 6
3	Adding 5-lb set to older 20-lb set from SR-406 (total of 25 lb), adding back space adaptation conditions, four crew members	27.5	Days 12, 13, 15, 16

TABLE VI.—SCENARIO S–435: ISS PROBABILISTIC RISK ASSESSMENT UPDATE

DRM	Description	Mission length, days	EVA (if applicable)
1	Uses results from newer IMM SR run (S–20200330-426 ISS PRA) to update the numbers provided in older IMM SR (S–20151123-341 RevA), assuming medical resources from current medical set on ISS	182.625	Days 45.65625, 91.3125, 136.9688

TABLE VII.—SCENARIO S–441: HSRB POINT OF DEPARTURE—BASIS OF COMPARISON

DRM	Description	Mission length, days	EVA (if applicable)
PoD	Point of departure	860	15 EVAs with two crew members performing EVAs
AS	Alternate short stay	1030	15 EVAs with two crew members performing EVAs
BoC	Basis of comparison	1224	94 EVAs with four crew members performing EVAs

2.1.6 S–441: Human Systems Risk Board (HSRB) Point of Departure—Basis of Comparison

Includes runs for Mars DRMs: the point of departure (PoD), alternate short stay (AS) and basis of comparison (BoC) (Table VII). These runs consisted of four crew members and various scheduled EVAs. For this request, the IMM team determined 10 conditions were unlikely to occur due to limited vehicle size at any time except for during a microgravity EVA. The IMM team modified the formally versioned IMM code so that the 10 conditions could not occur outside of the scheduled EVA times. MEDPRAT V2.0 is used for this comparison as it provides the ability to handle this scenario using the condition segments feature. This is based on IMM SR S–20210809–441.

2.1.7 S–442: Risk Posture for Exploration Mission Analysis Cycle (EMAC) 4.0 Artemis IV

In all DRMs for S–442, an Orion/Gateway scenario with four crew members is simulated (Table VIII). Due to the limited vehicle size consisting of a single module, limited movement of crew, and lack of exercise equipment, many conditions relating to these are removed. All DRMs are using an optimized medical set. This is based on IMM SR S–2022330–442.

2.1.8 S–406: Orion Medical Set Contents

The Orion medical set contents analysis report provides an optimized medical set based on a 9.07-kg mass constraint and an alternate set based on a 9.07-kg mass and 13,721-cm^3 volume constraint (Table IX). The 21-day mission used to generate these optimized sets consists of four crew members with no scheduled EVAs. This is based on IMM SR S–20180815–406.

TABLE VIII.—SCENARIO S–442: RISK POSTURE FOR EMAC 4.0 ARTEMIS IV

DRM	Description	Mission length, days	EVA (if applicable)
15day_opt	Outbound up to 7 days on Orion, inbound 5 days on Orion, 3 days on Gateway	15	None
17day_opt	Outbound up to 7 days on Orion, inbound 5 days on Orion, 5 days on Gateway	17	None
23day_opt	Outbound up to 7 days on Orion, inbound 5 days on Orion, 11 days on Gateway	23	None

TABLE IX.—SCENARIO S–406: ORION MEDICAL SET CONTENTS

DRM	Description	Mission length, days	EVA (if applicable)
1	Orion	21	None

3.0 Results

3.1 Comparing Condition Occurrences

In this section, results for the mean condition occurrence averaging at least one occurrence and its corresponding 95 percent CI, assuming a normal distribution, of the population are graphed for each respective scenario and DRM for both MEDPRAT and IMM. In order to provide readable graphs, the graphical results are truncated and show condition occurrence means averaging at least one per mission, with the exception of scenario S–412, which has two DRMs with a short mission length of 7.5 days; as such, the minimum threshold is lowered to 0.1 average events per mission. Mean condition occurrences reported are for the limited treatment paradigm and are defined as the total condition occurrences divided by the total number of trials. For each scenario, MEDPRAT V1.0 and V2.0 are run with 300,000 trials. For every scenario except S–442, IMM was run with 100,000 trials. IMM was run with 300,000 trials in scenario S–442. All the MEDPRAT V2.0 predicted means and almost all the MEDPRAT V1.0 predicted means are within the IMM predicted CI. Only one mean for MEDPRAT V1.0, namely, Paresthesias Secondary to EVA condition in the S–441 scenario AS DRM, is outside of the IMM CI. Because the magnitude of this exceedance beyond the IMM CI upper bound is less than 0.2 and the mean number of occurrences for Paresthesias Secondary to EVA for MEDPRAT V1.0 is 7.68; this can be considered a slight deviation.

For longer duration missions, MEDPRAT V2.0 means tend to be higher than IMM means (e.g., S–386 DRM 1, 2, 3; S–387 DRM 3, 6, 9; and S-441 DRM BoC). MEDPRAT V2.0 is expected to report more total medical events for longer missions given that crew members are kept in the simulation after being flagged for RTDC as stated in assumption 2. Although the effect of this assumption is more notable in the untreated paradigm, at the condition occurrence level this effect can be seen to a small degree for longer missions, but the effect is not large enough to cause the predicted mean to be outside of the IMM CI for the scenarios considered here. Both MEDPRAT V1.0 and V2.0 CIs are narrower for some of the conditions, as expected due to the difference in the number of trials between the IMM and MEDPRAT models, save for S–442 with IMM, which was run with 300,000 trials as well. Larger numbers of trials can drive the individual condition occurrence standard deviation down, further causing a tighter CI.

Higher resolution graphs are available at https://ccmp.gitlab.grc.nasa.gov/chp-pra/results/ and can be accessed with appropriate NASA credentials.

3.1.1 S–386: Risk of Appendicitis and Cholecystitis Versus Risk of SBO Following Prophylactic Surgery

See Figure 1 to Figure 4.

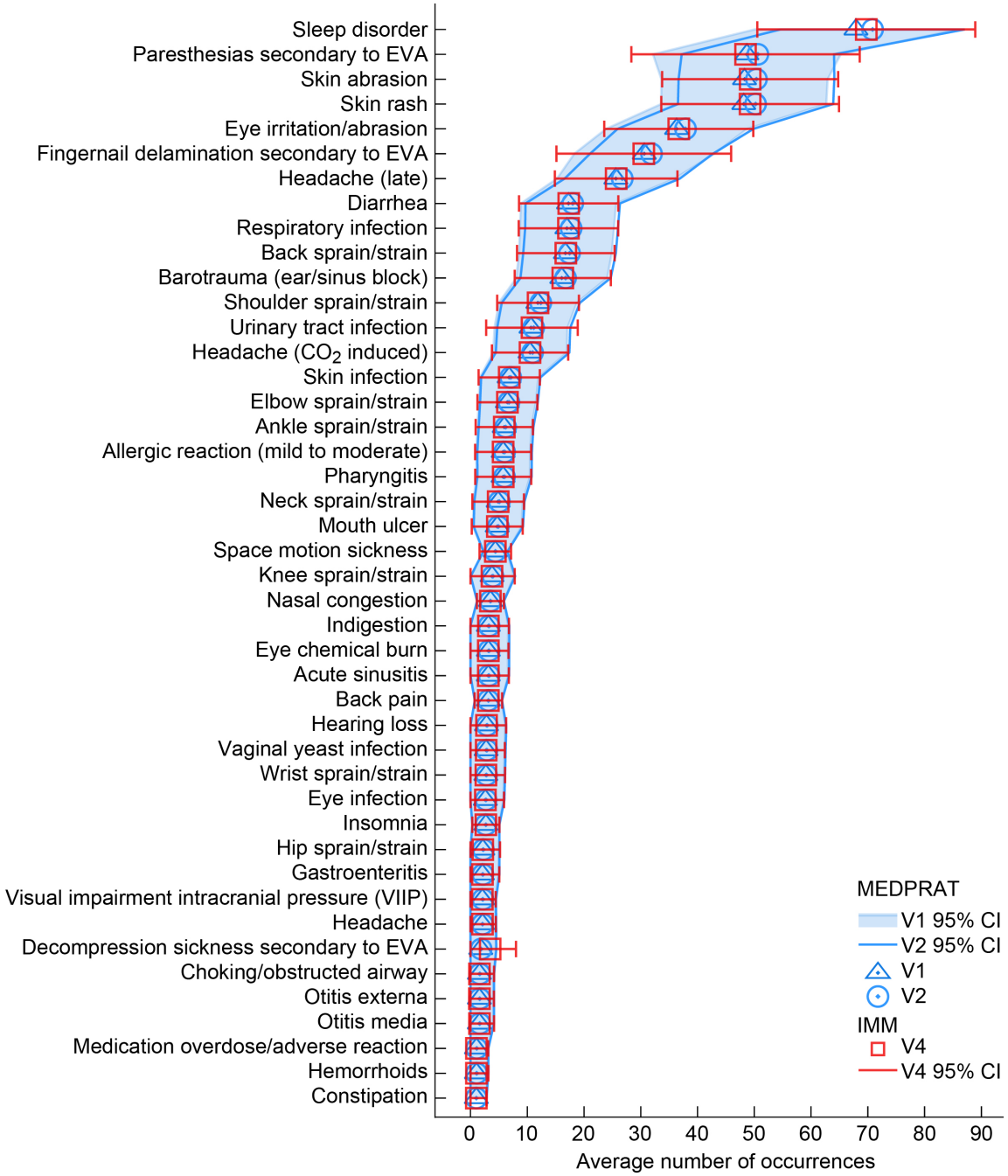

Figure 1.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 1.

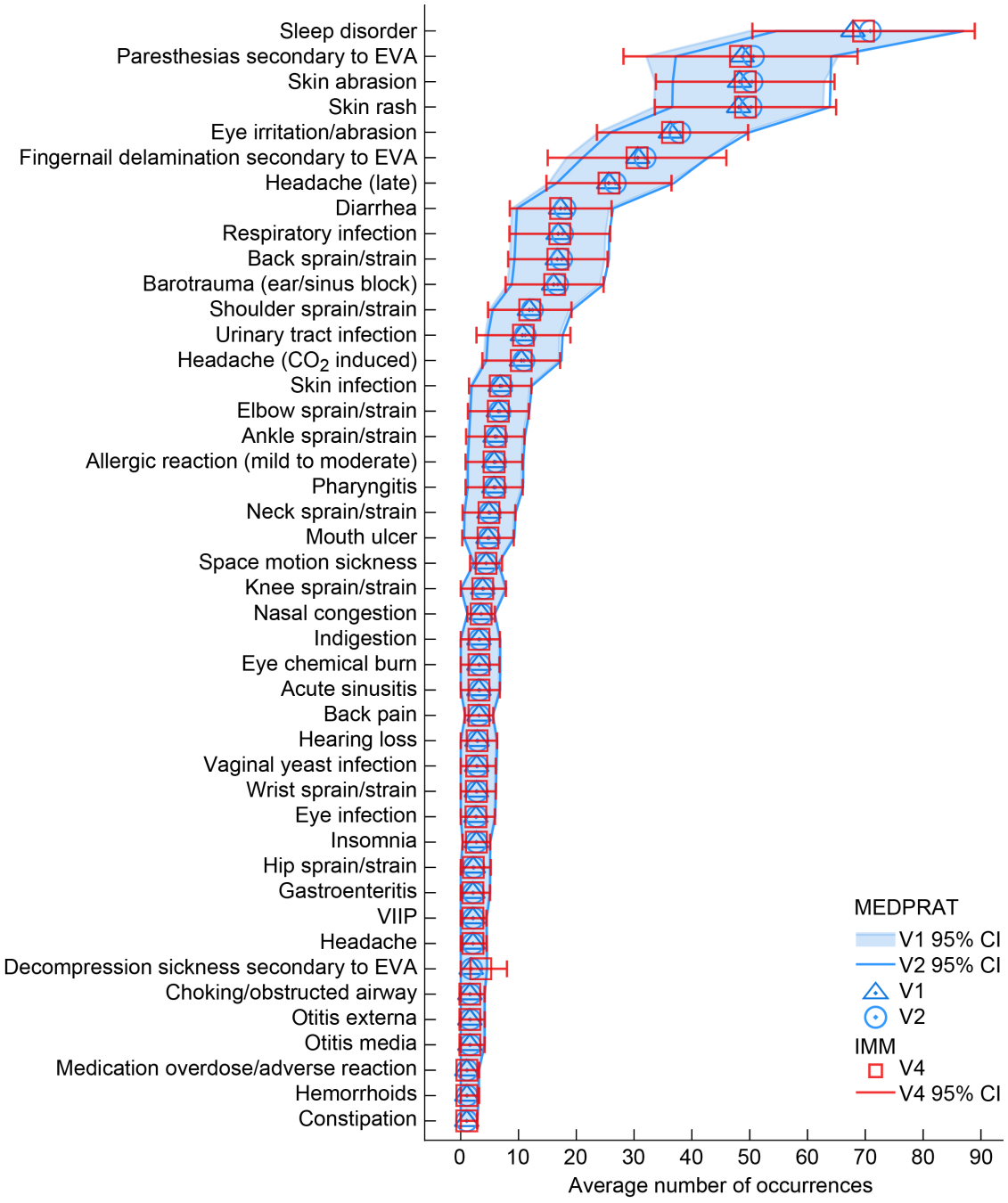

Figure 2.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 2.

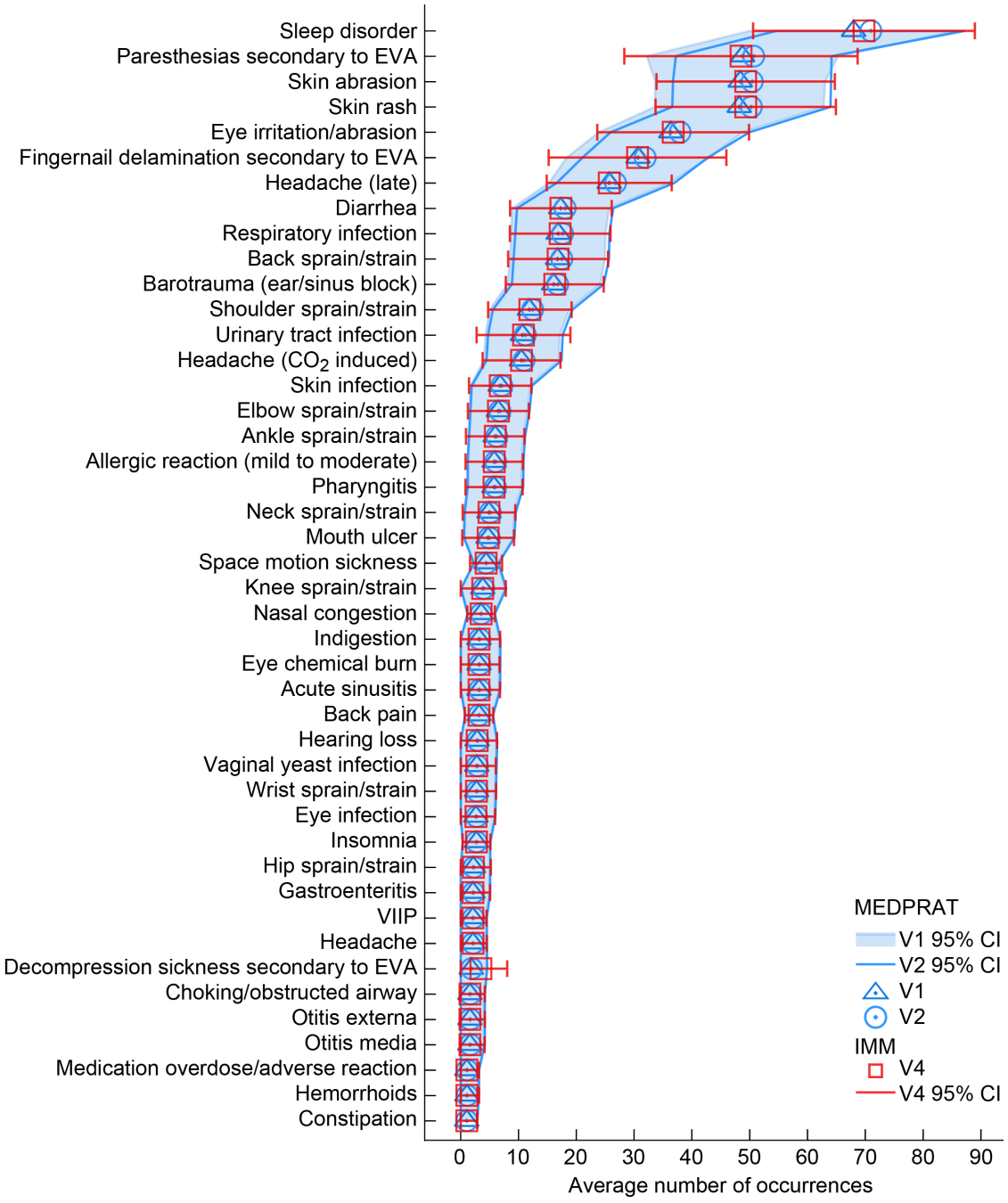

Figure 3.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 3.

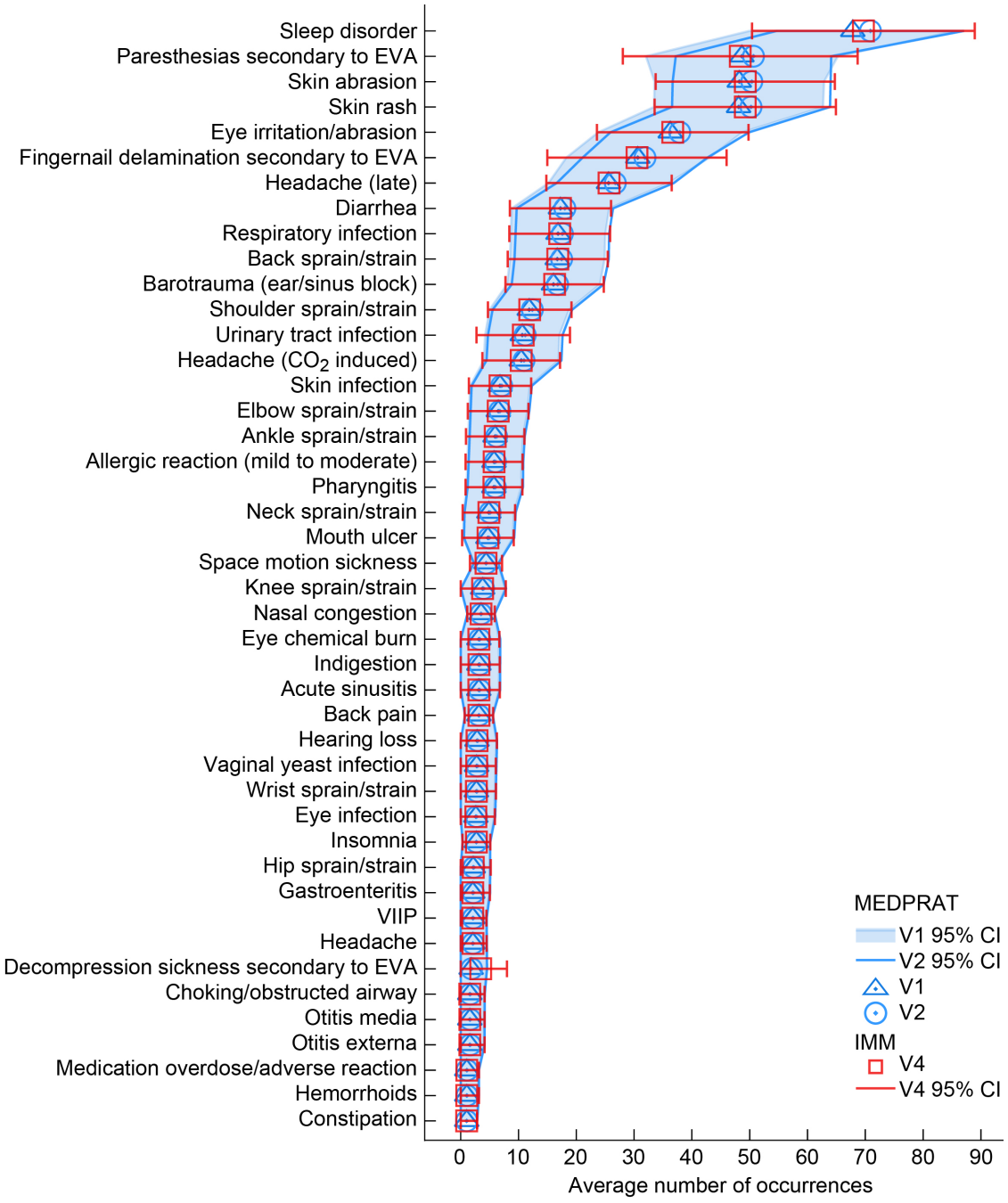

Figure 4.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 4.

3.1.2 S–387: Impact of Sex on Medical Outcomes for Deep Space Missions

See Figure 5 to Figure 13.

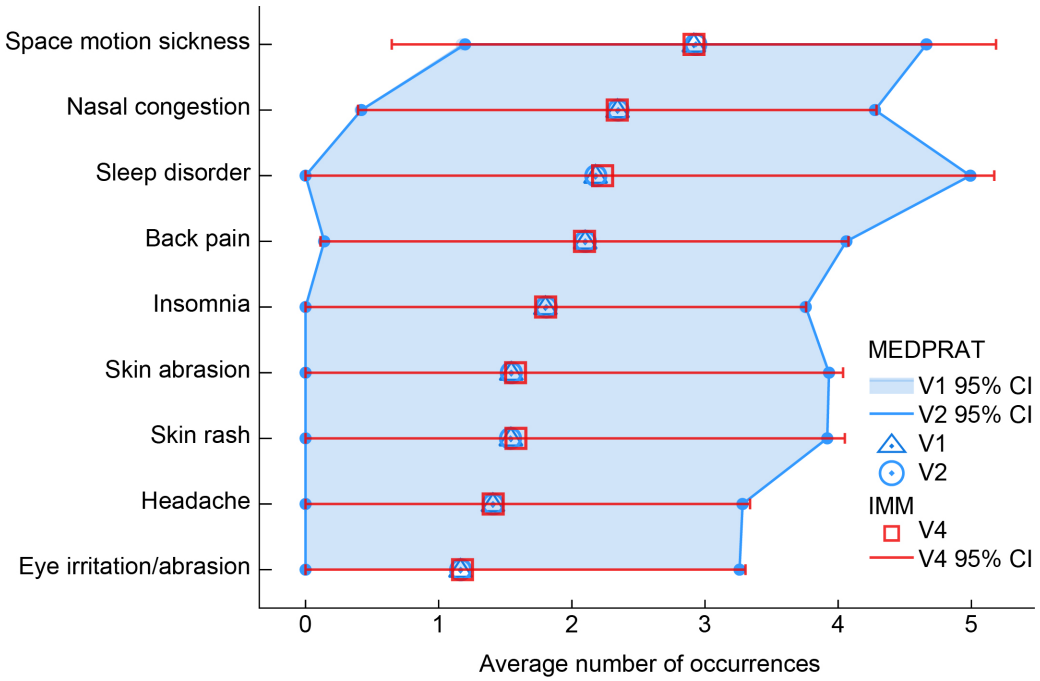

Figure 5.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 1.

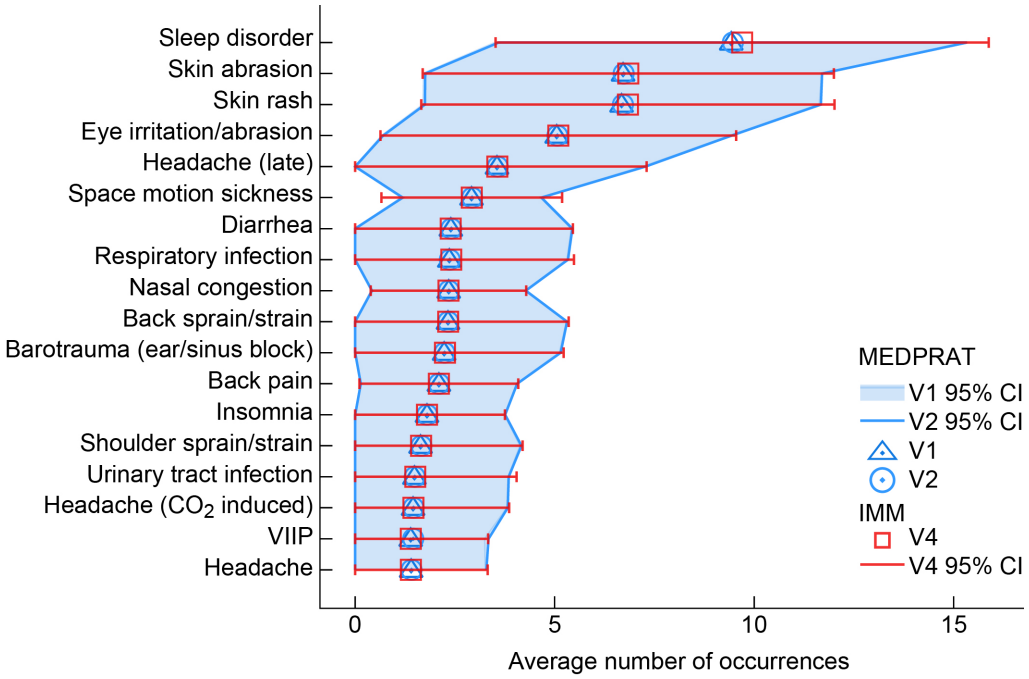

Figure 6.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 2.

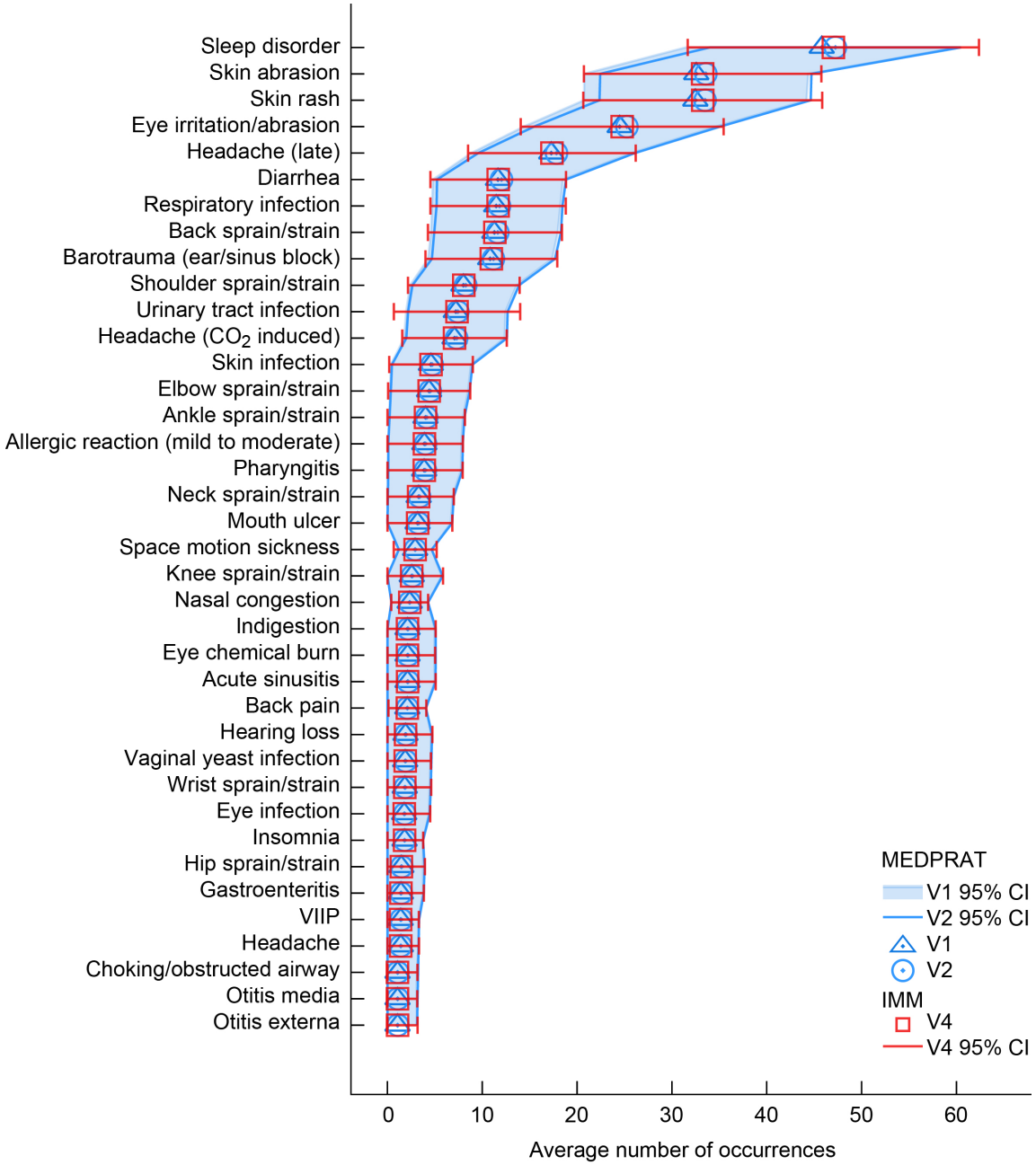

Figure 7.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 3.

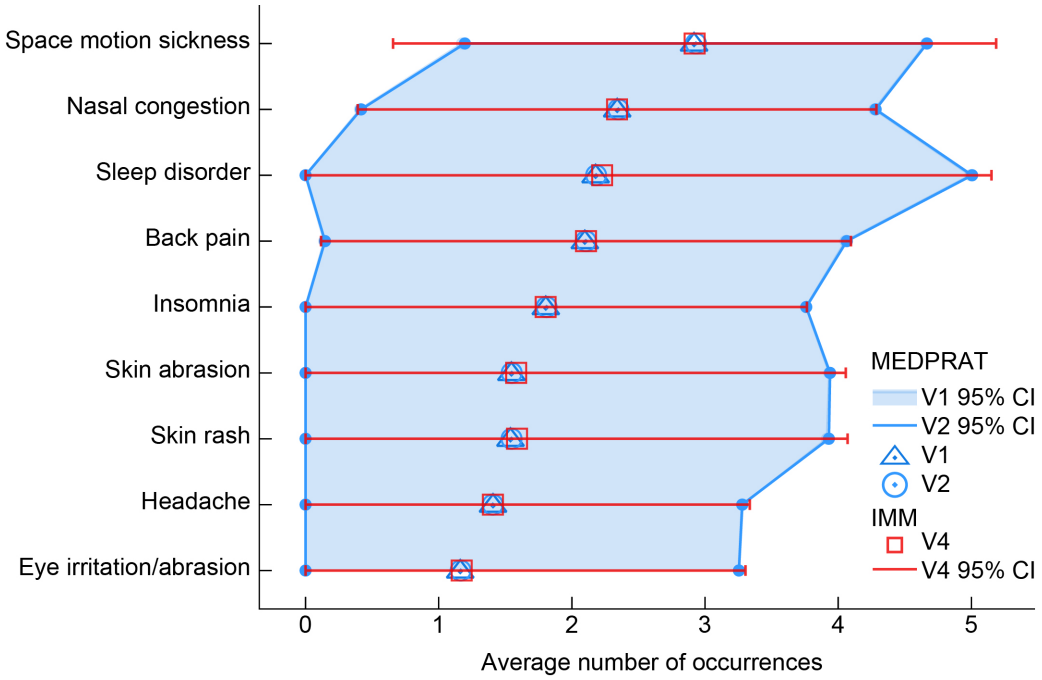

Figure 8.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 4.

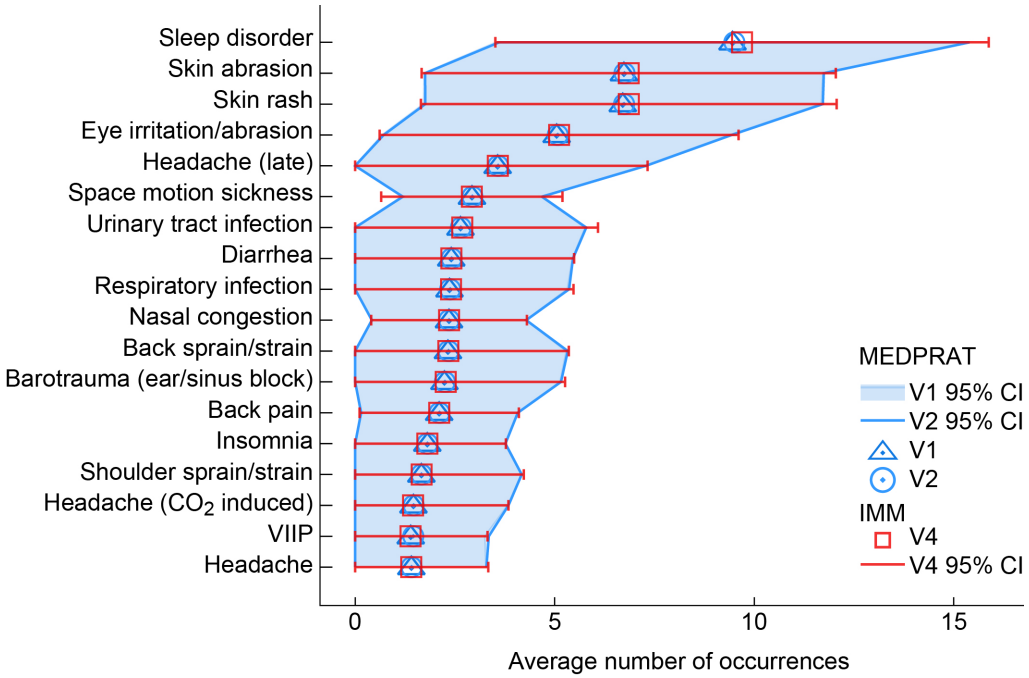

Figure 9.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 5.

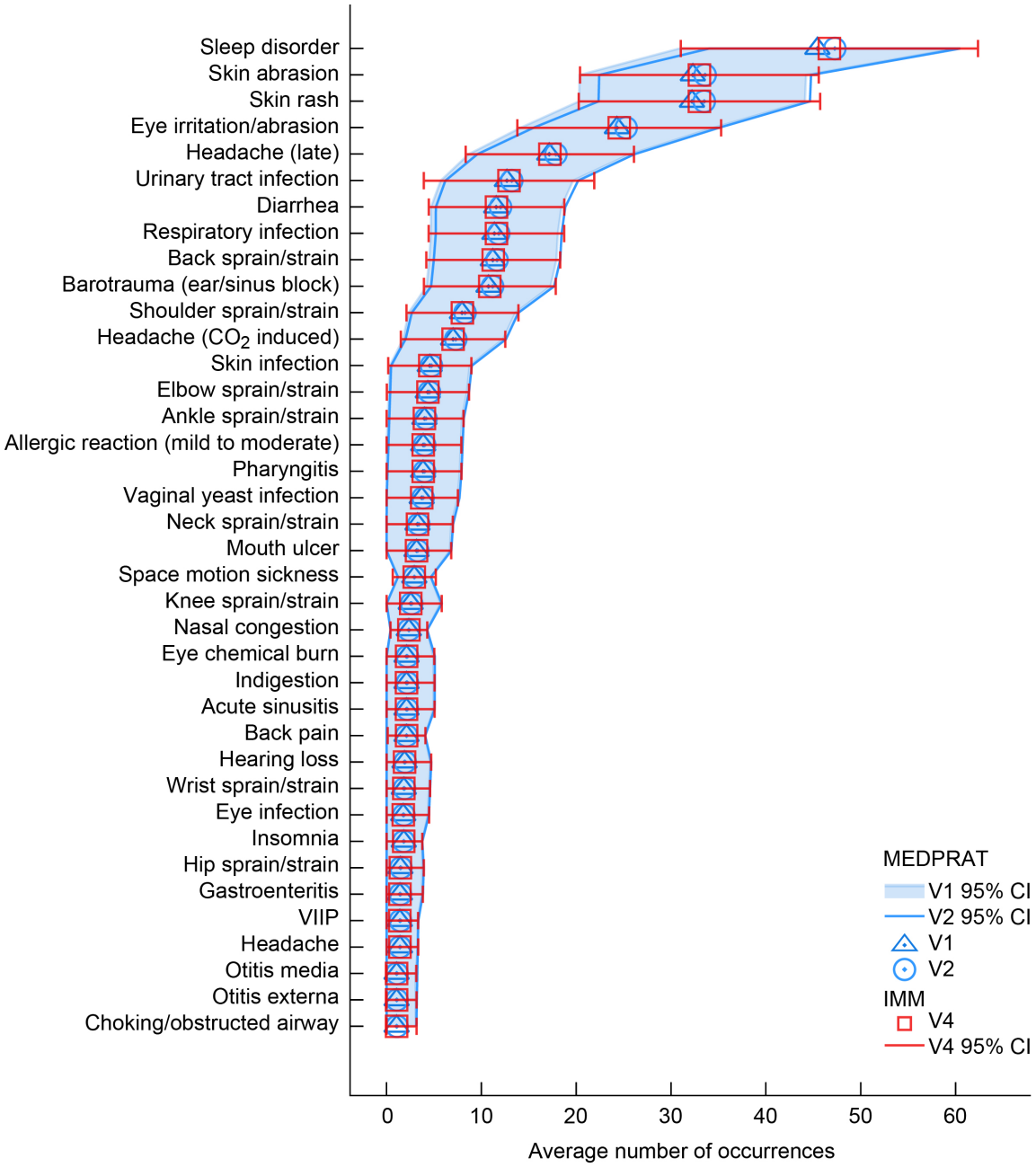

Figure 10.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 6.

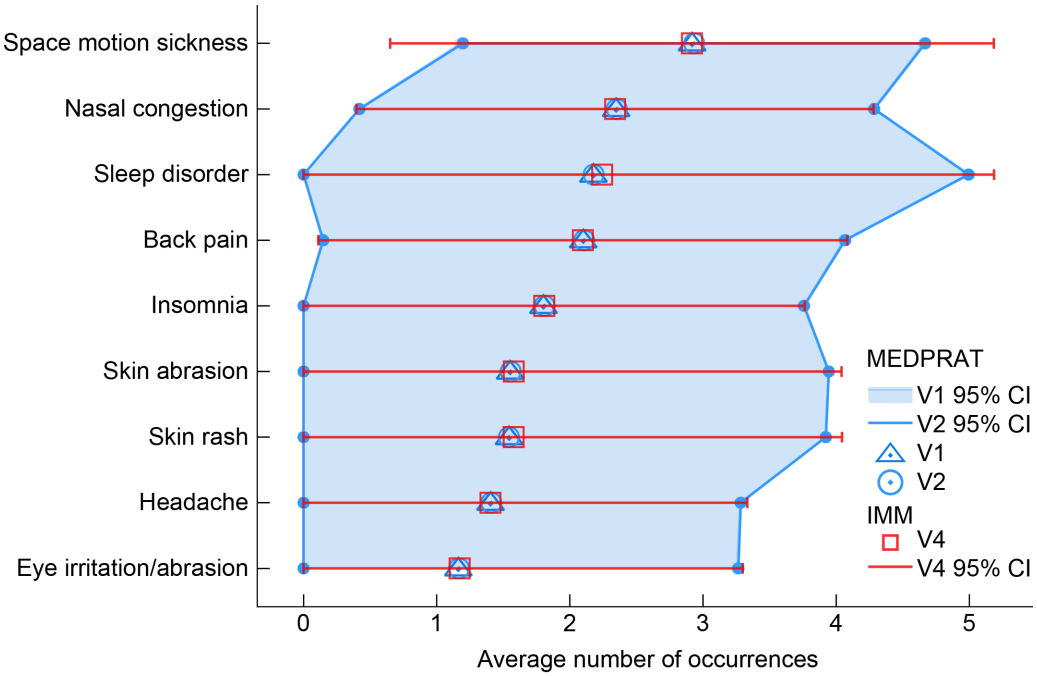

Figure 11.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 7.

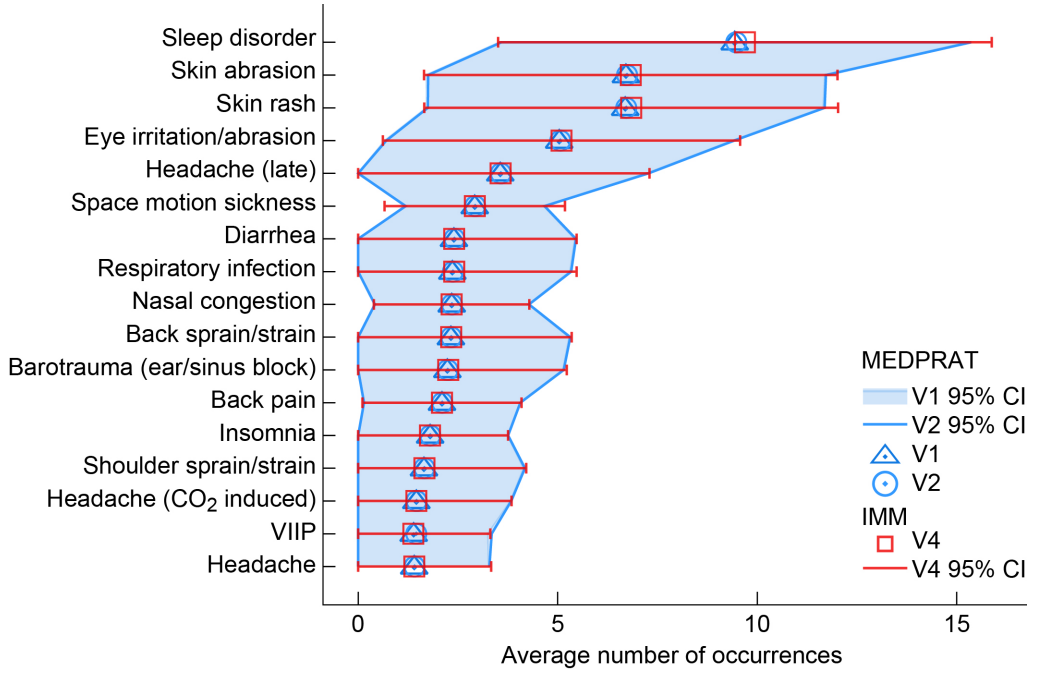

Figure 12.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 8.

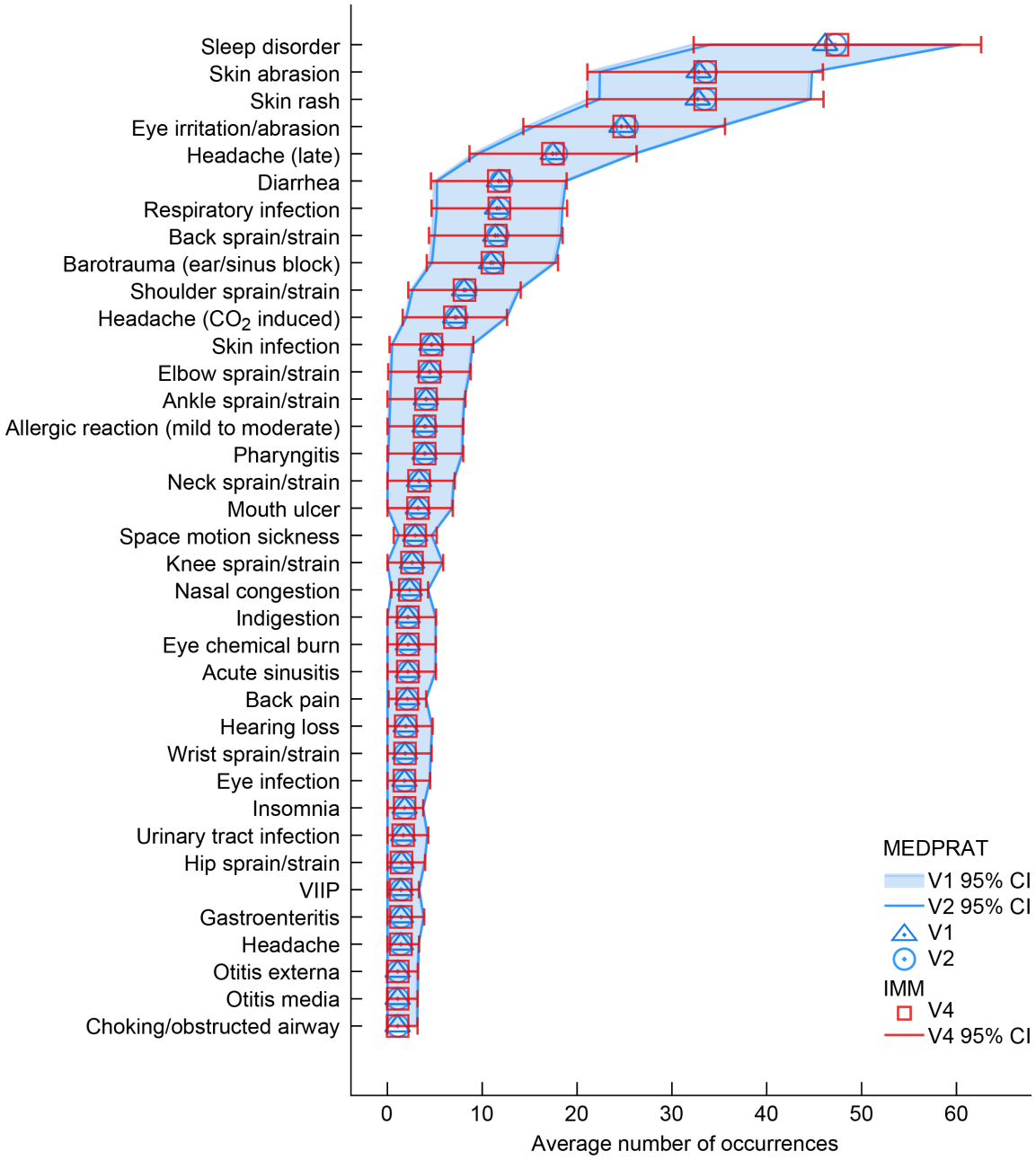

Figure 13.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 9.

3.1.3 S–388: Impact of Heroic Medical Care Measures on Subsequent Medical Outcomes

See Figure 14 to Figure 18.

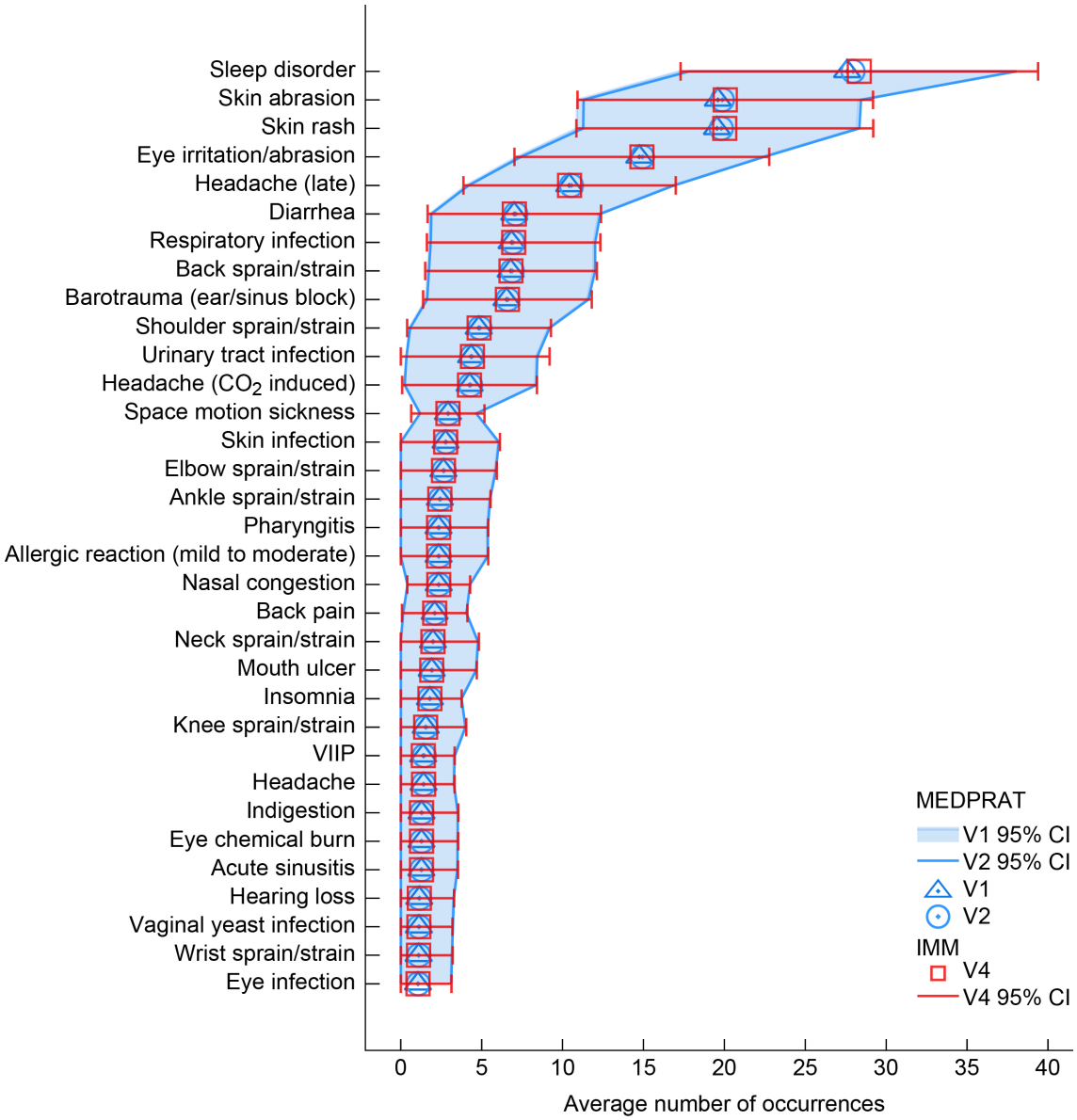

Figure 14.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 1.

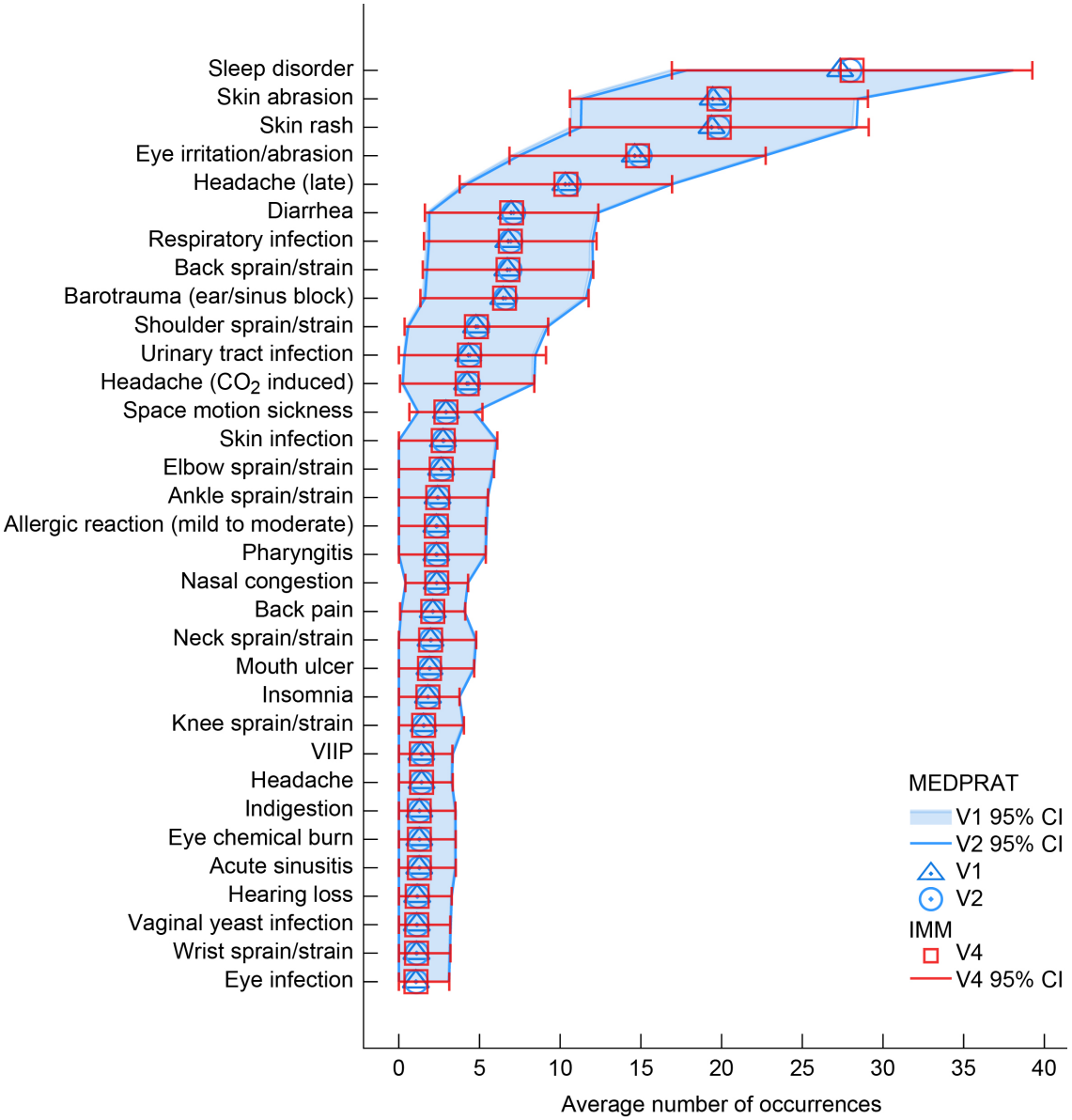

Figure 15.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 2.

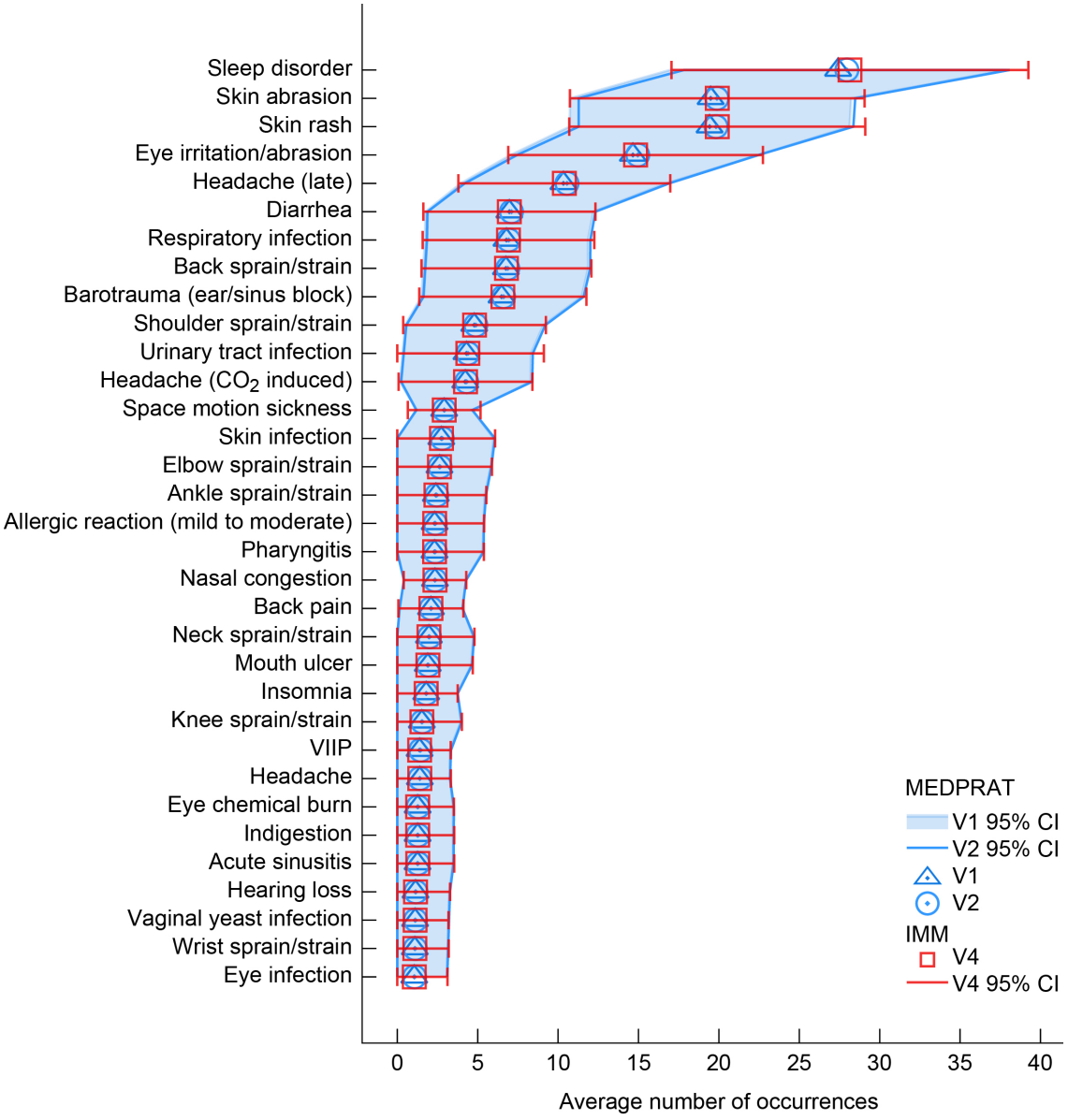

Figure 16.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 3.

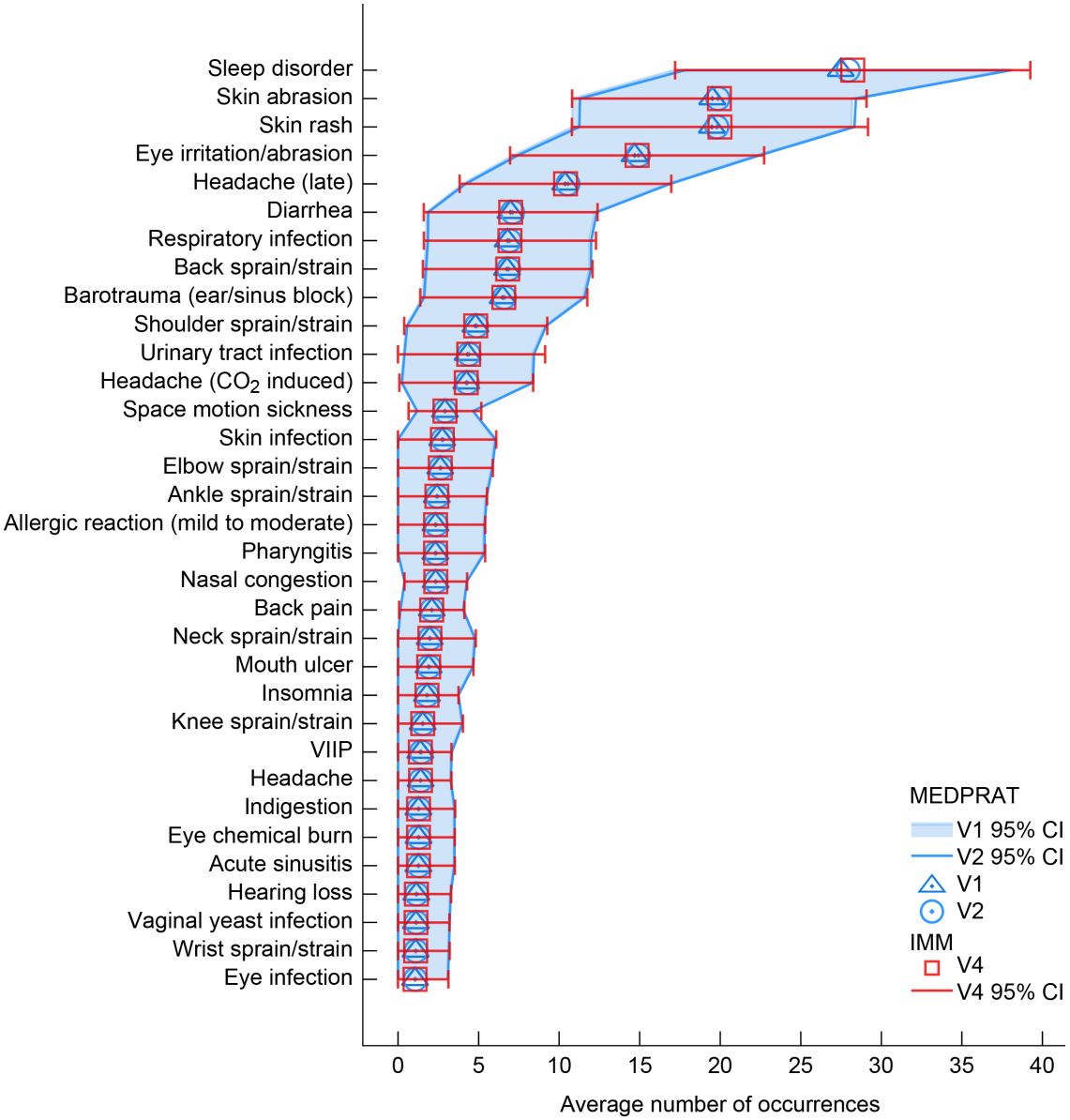

Figure 17.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 4.

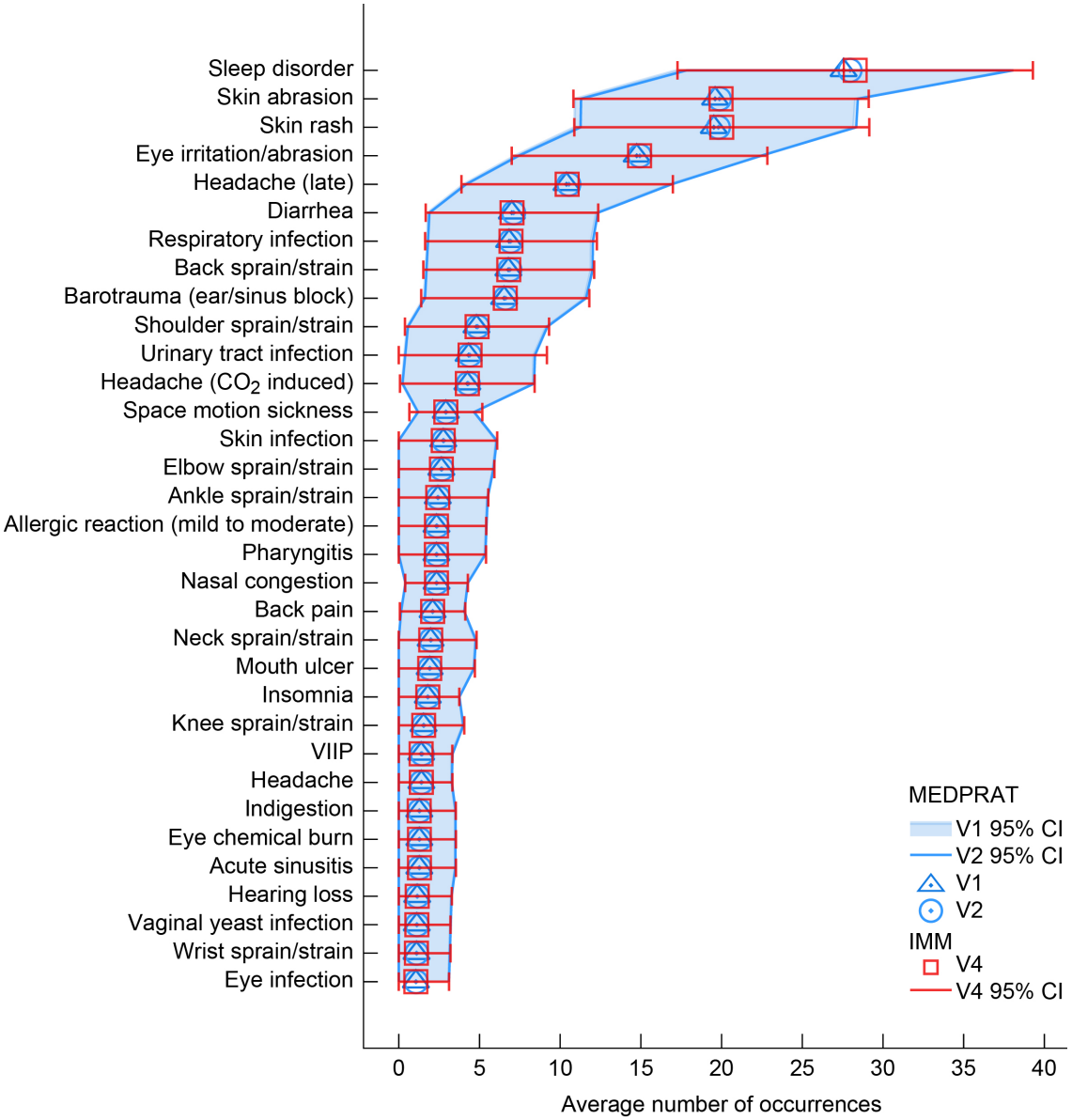

Figure 18.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 5.

3.1.4 S–412: Lunar 27.5-Day and 7.5-Day Assessment

See Figure 19 to Figure 21.

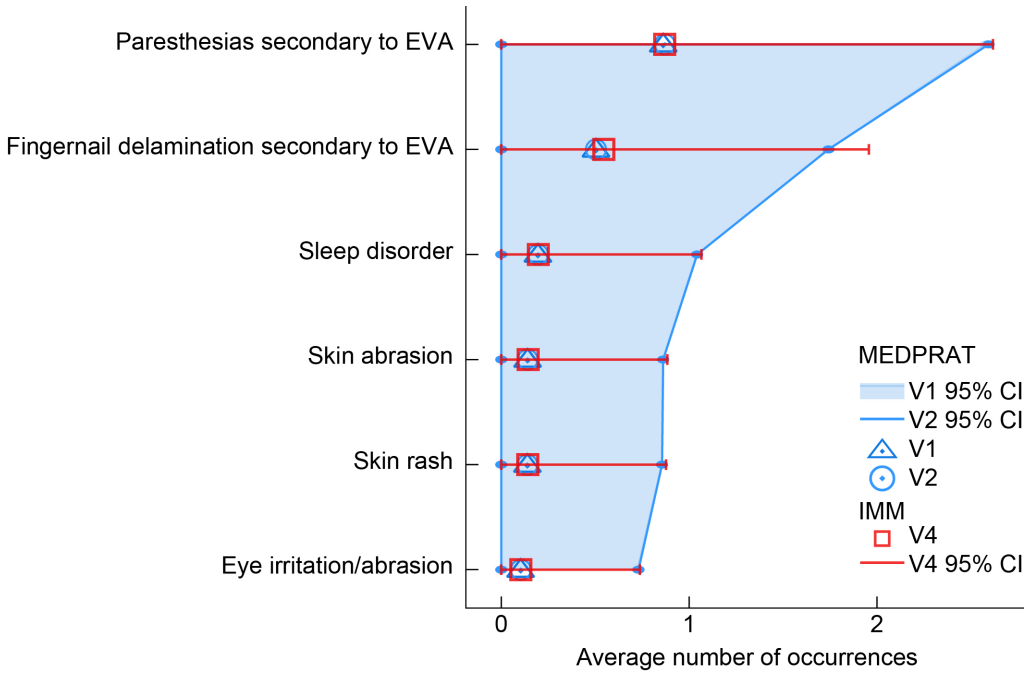

Figure 19.—Average number of occurrences for conditions with at least 0.1 mean occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for 7p5day.

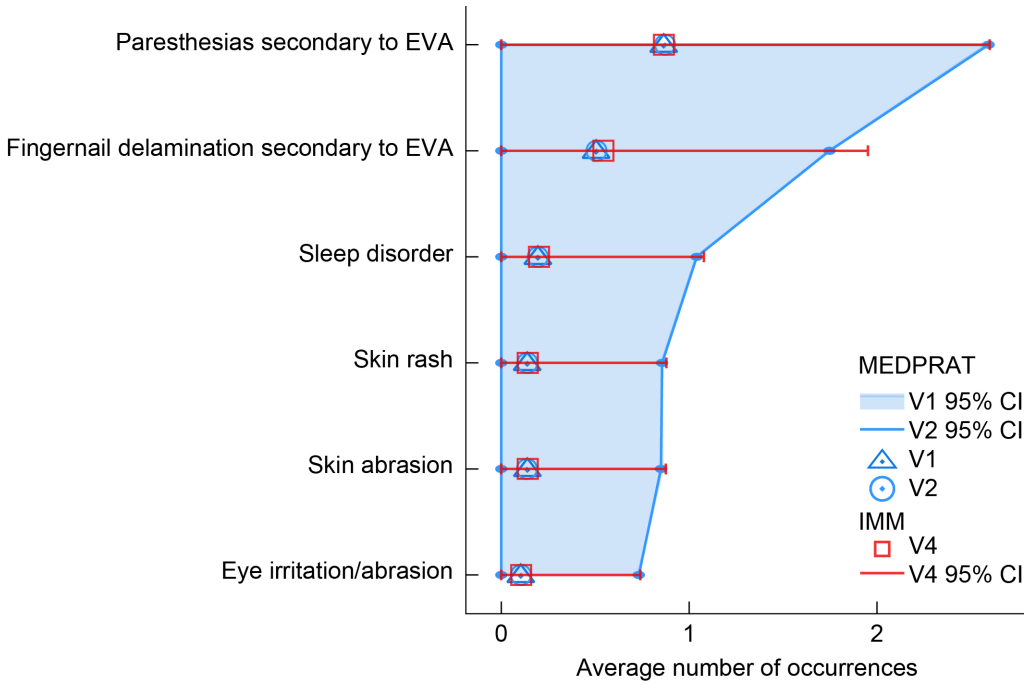

Figure 20.—Average number of occurrences for conditions with at least 0.1 mean occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for 7p5day_opt.

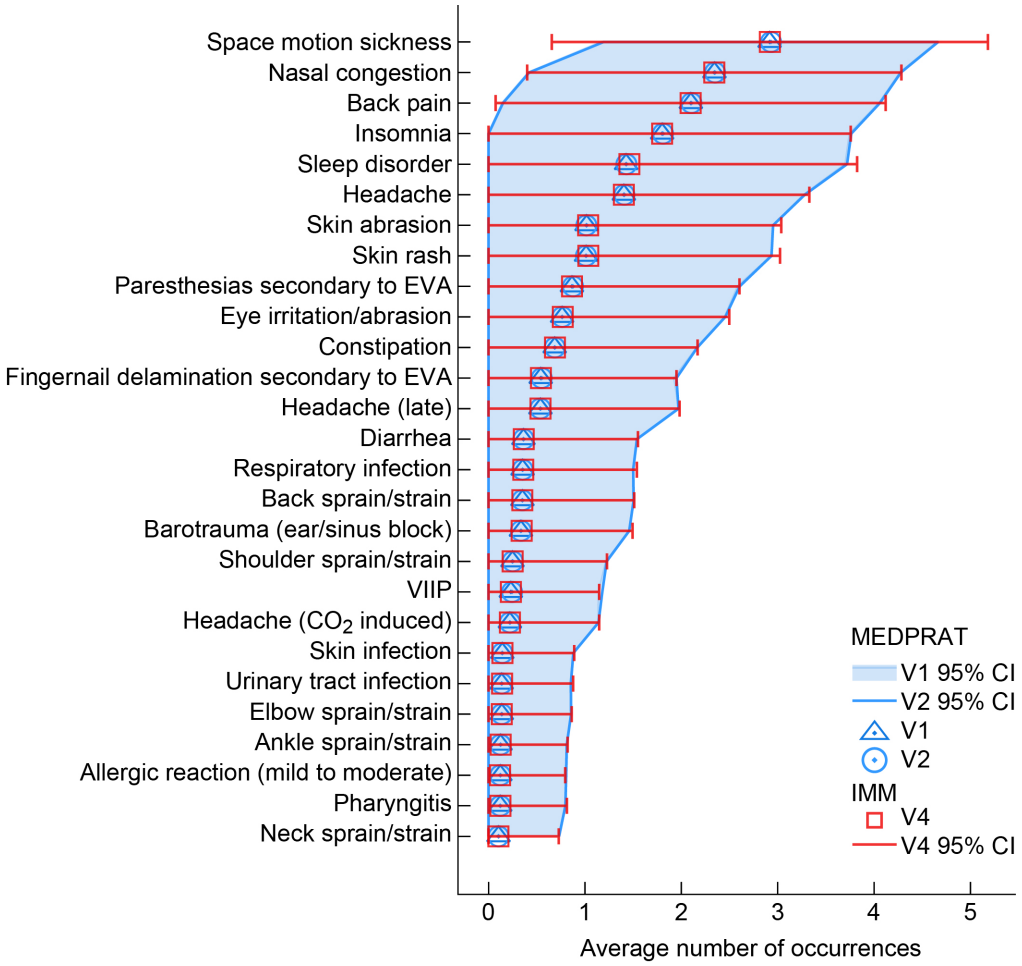

Figure 21.—Average number of occurrences for conditions with at least 0.1 mean occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for 27p5day.

3.1.5 S–435: ISS Probabilistic Risk Assessment Update

See Figure 22.

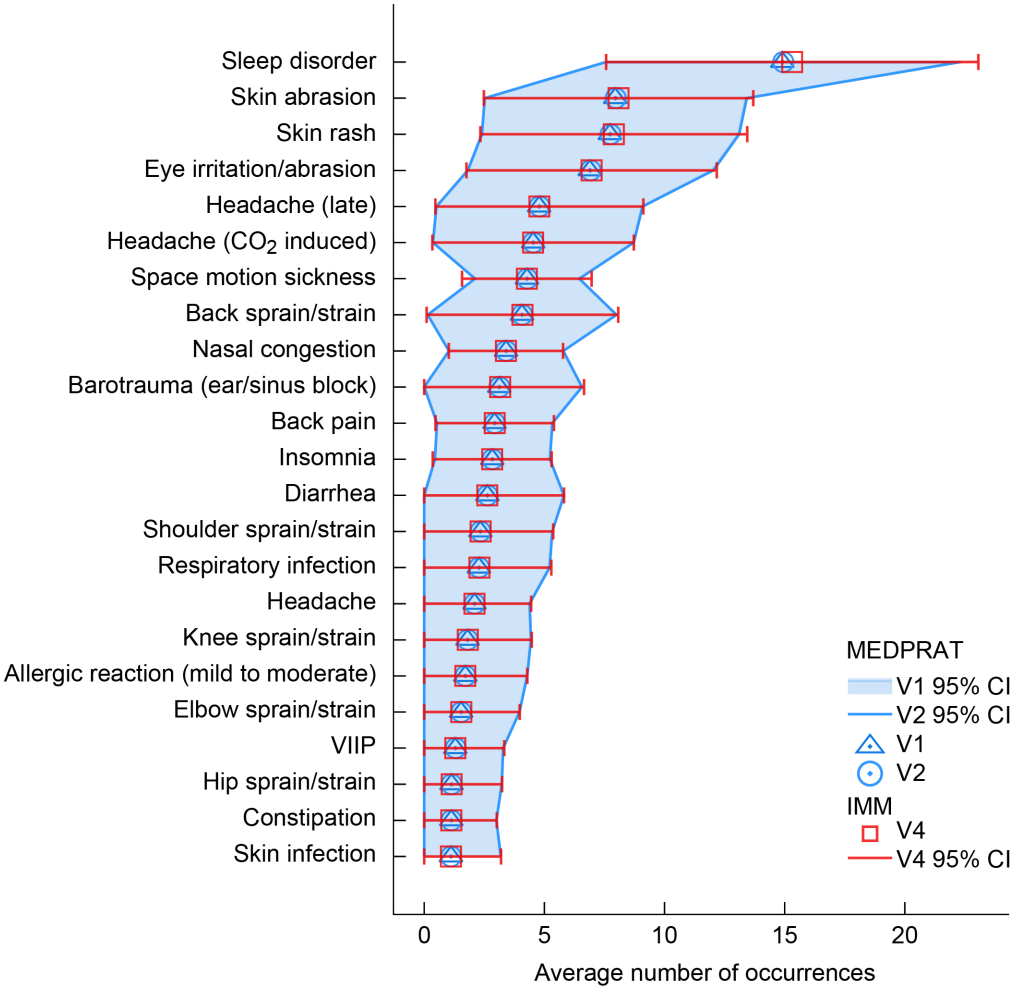

Figure 22.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for DRM 1.

3.1.6 S–441: HSRB Point of Departure—Basis of Comparison

See Figure 23 to Figure 25.

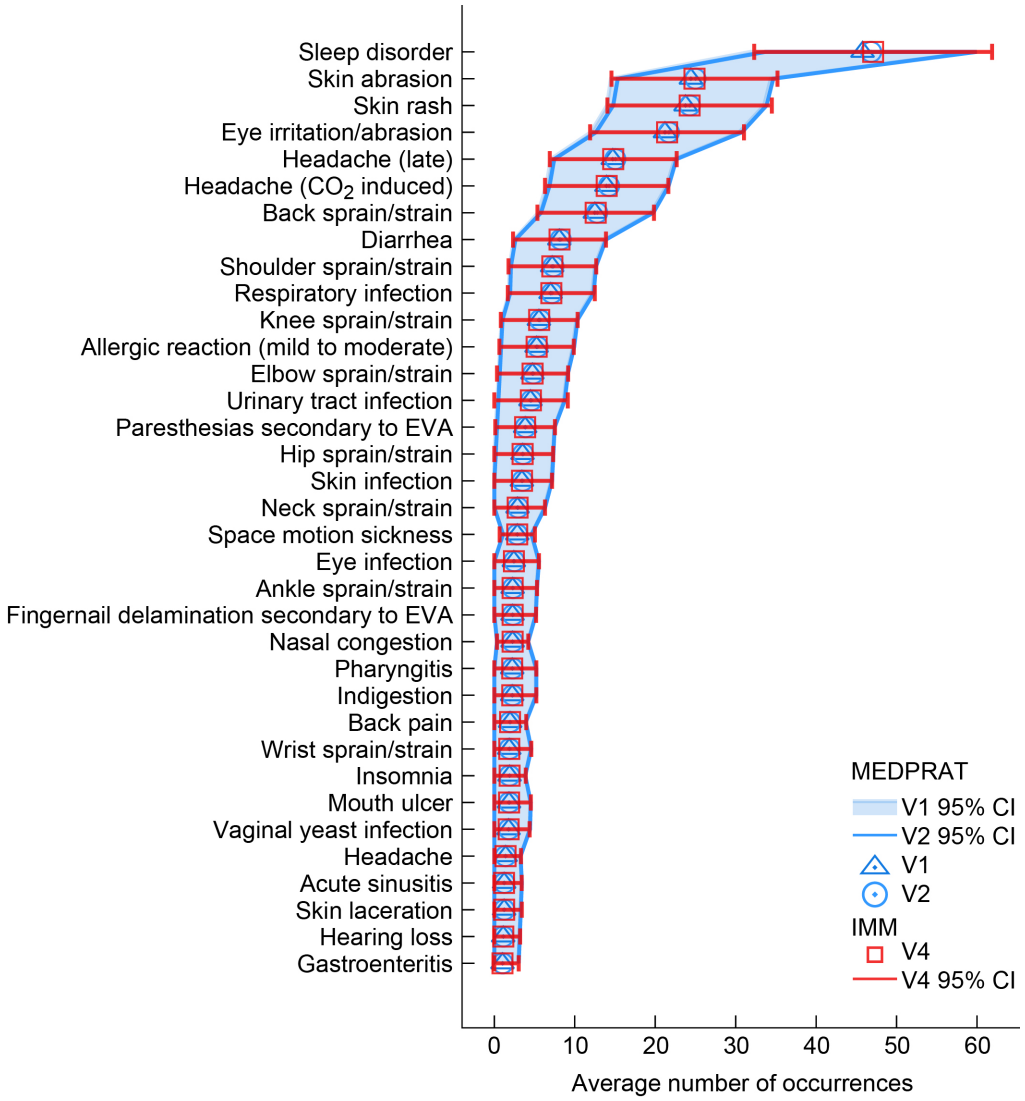

Figure 23.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for PoD.

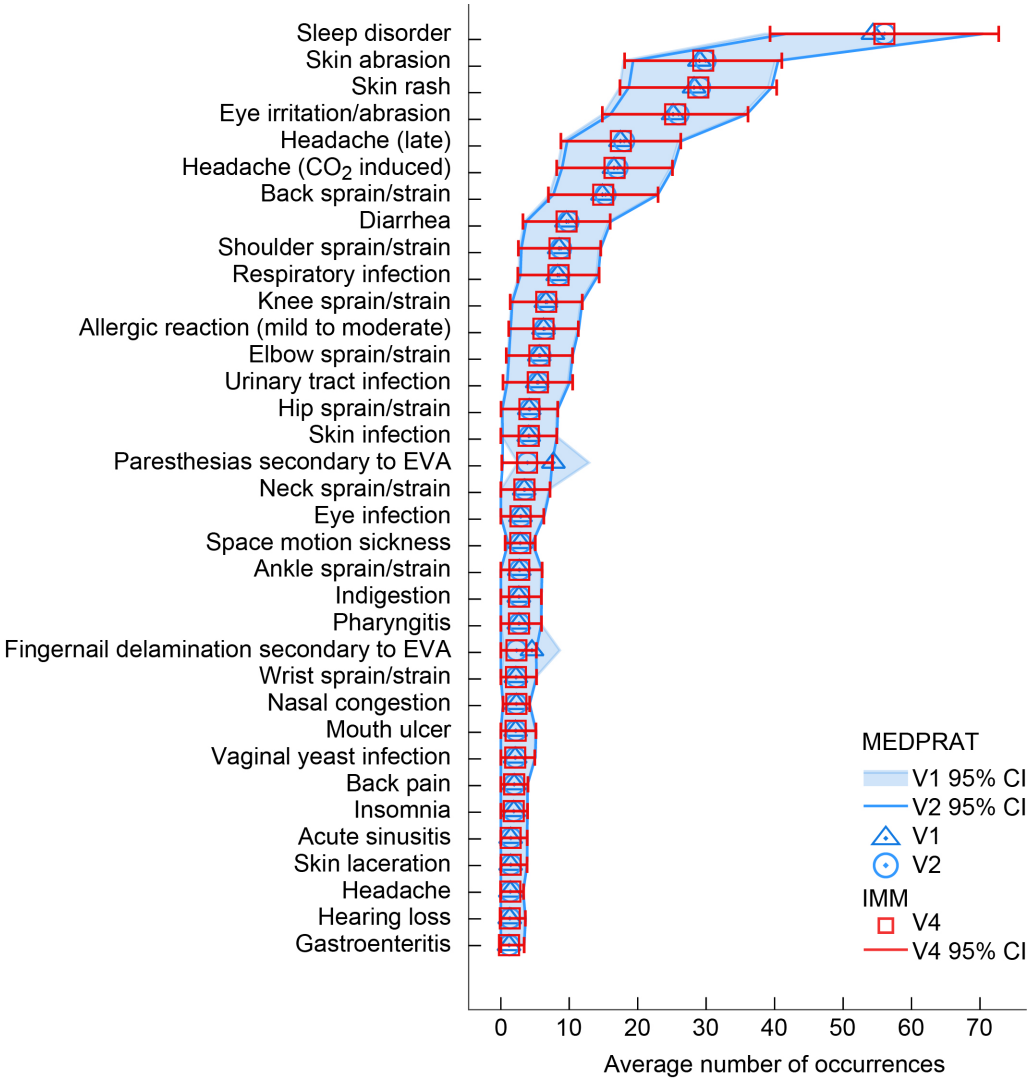

Figure 24.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for AS.

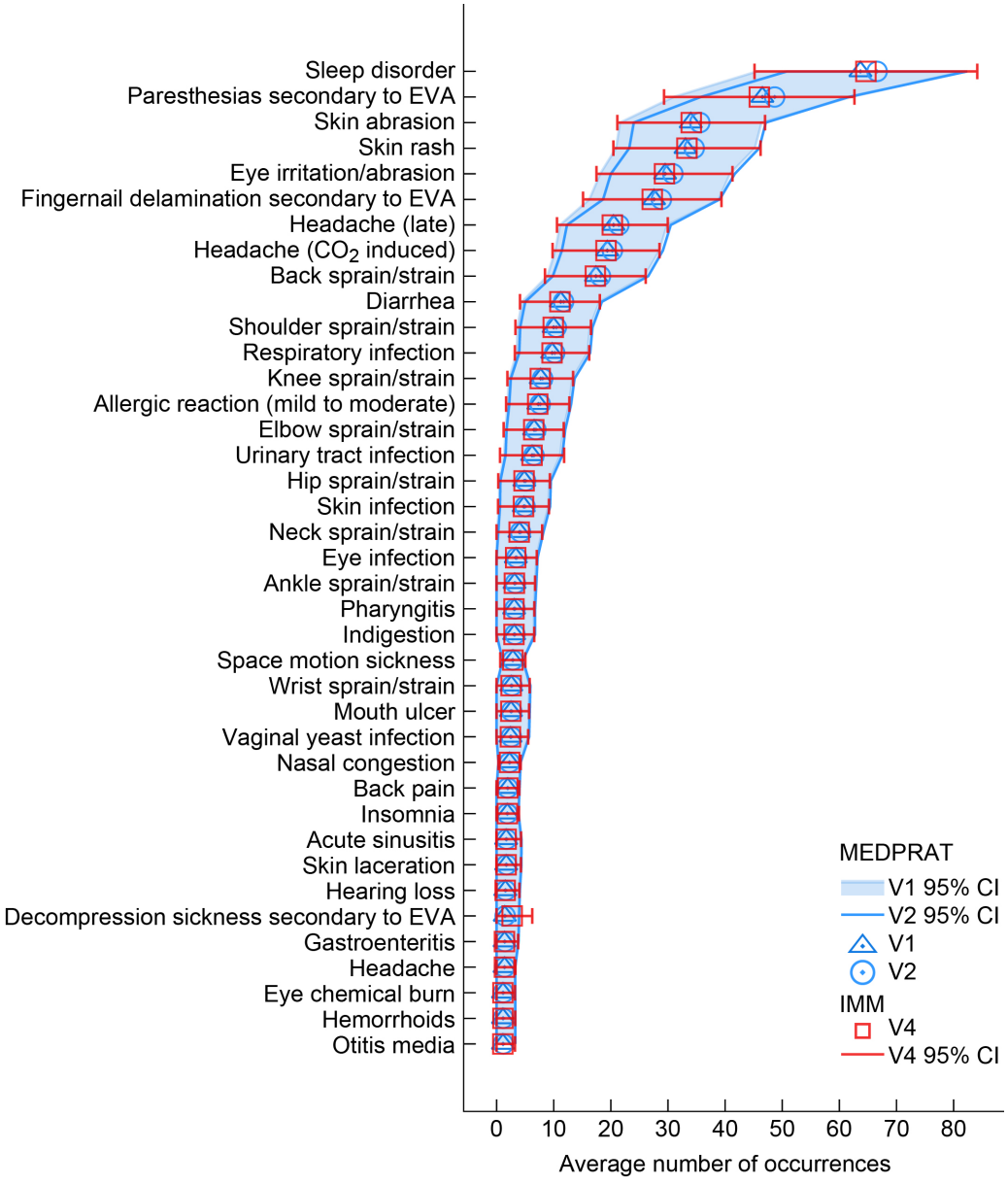

Figure 25.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for BoC.

3.1.7 S–442: EMAC 4.0 Artemis IV

See Figure 26 to Figure 28.

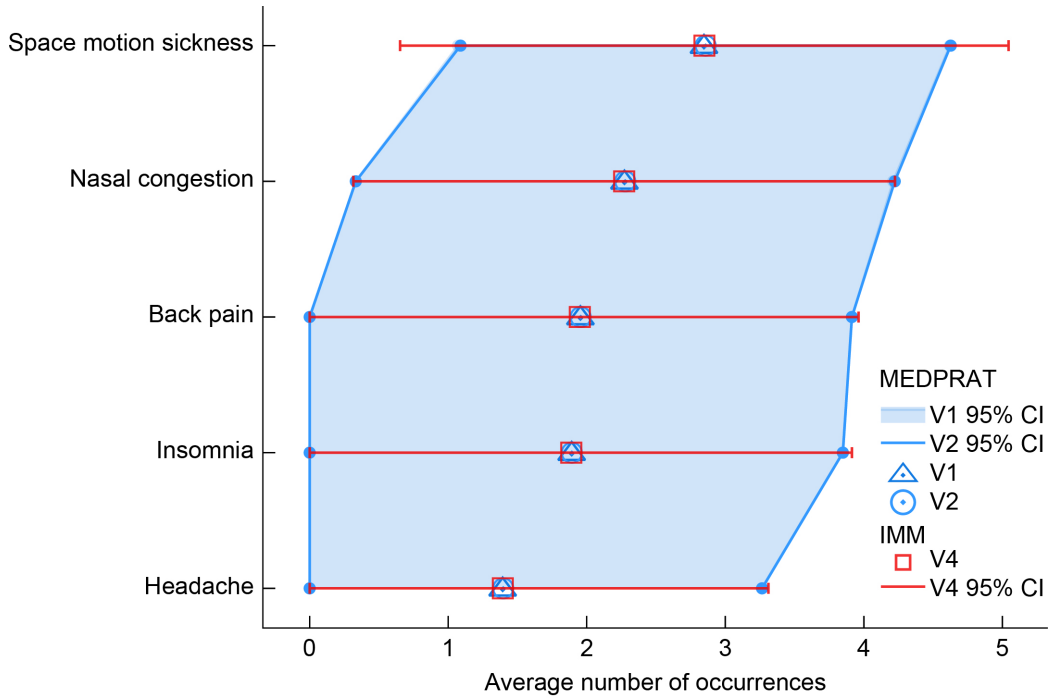

Figure 26.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for 15day_opt.

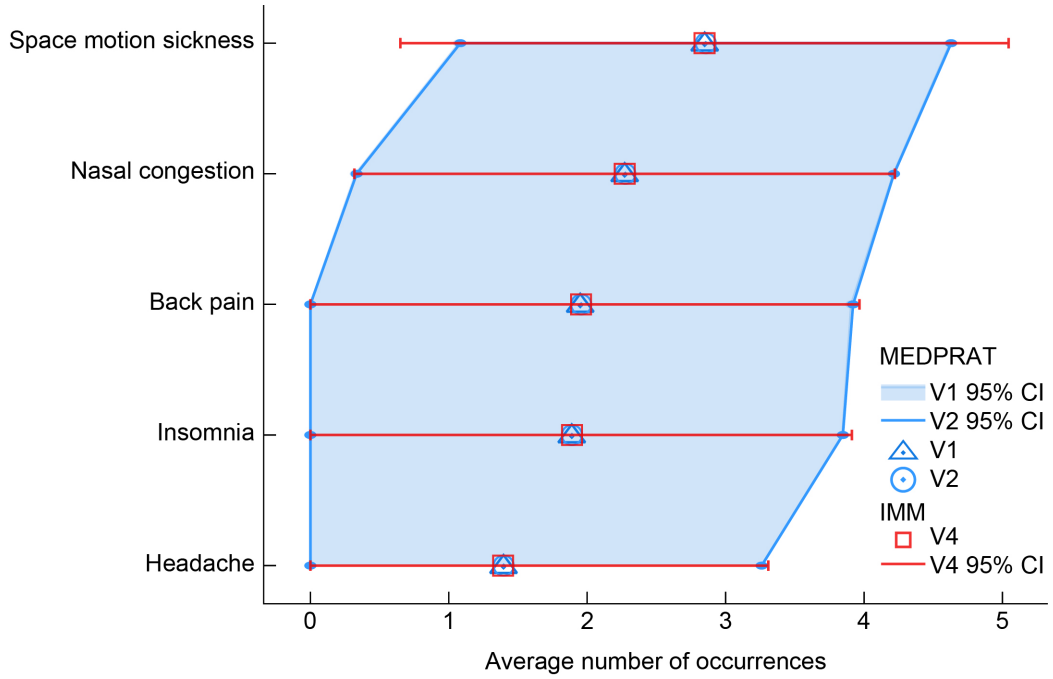

Figure 27.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for 17day_opt.

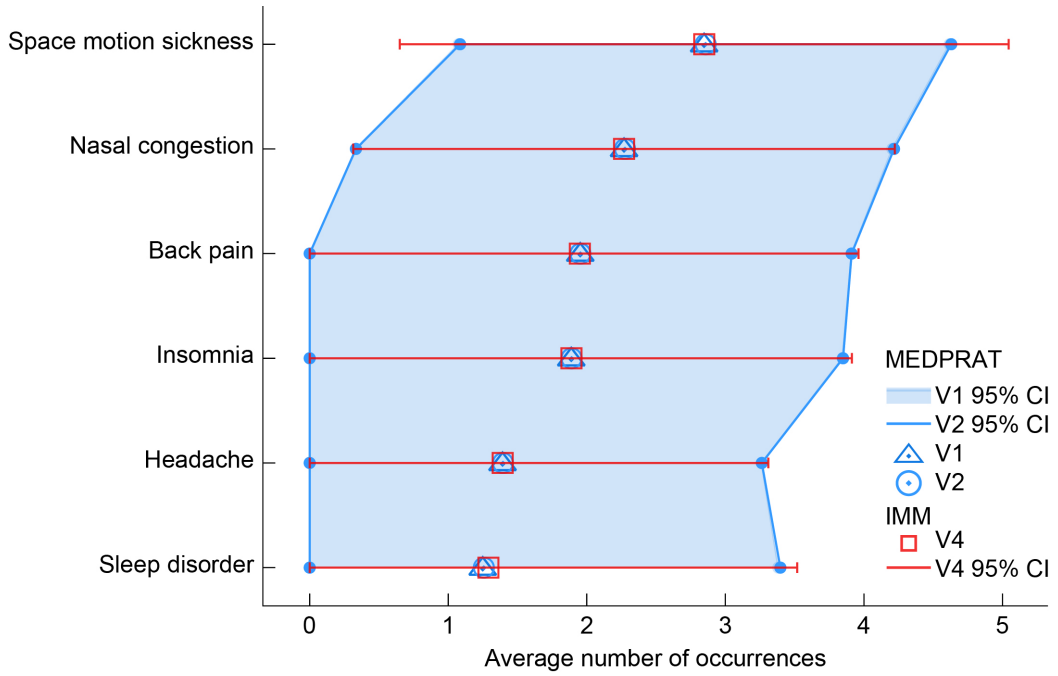

Figure 28.—Average number of occurrences for conditions with at least one occurrence for IMM, MEDPRAT V1.0, and MEDPRAT V2.0 with their respective 95 percent population CI for 23day_opt.

3.2 Comparing Mission-Level Metrics

The results shown in this section provide the TME, CHI, EVAC/RTDC, and LOCL for each respective scenario, DRM, and treatment paradigm. The TME and CHI are defined as an average given that the total aggregate sum across all trials for each risk metric is divided by the total number of trials (100,000 for IMM except S–442 and 300,000 for MEDPRAT). For the RTDC and LOCL shown in the tables in this section, the mean values reported by MEDPRAT V1.0 and V2.0 (the total sum of RTDCs or LOCLs divided by the number of trials) are converted into probabilities of at least one RTDC (for RTDC) or at least one LOCL (for LOCL) occurrence happening per trial in order to facilitate direct comparison with IMM, which reports RTDC and LOCL as probabilities. This conversion is performed using a separate program that parses output from MEDPRAT. It is a relatively rare occurrence where more than one RTDC or LOCL occurs in a trial and usually only for long-duration missions, so the mean and probability values are actually very similar in practice. It should be noted that the effects of assumption 2 will not be as perceptible with these converted probabilities for MEDPRAT V2.0 RTDC and LOCL outcomes because they consider the probability of only the first occurrence and additional RTDCs or LOCLs after the first one do not affect this probability metric. To emulate IMM's methodology as closely as possible and so as to not presuppose normality of the data, the CIs for TME and CHI are the 5th and 95th percentiles, and the CIs for EVAC/RTDC and LOCL are calculated using the 5th and 95th percentiles of a bootstrap sampling routine with 1,000 resamples. In all tables, the cell is bolded whenever the MEDPRAT V1.0 and V2.0 mean (TME/CHI) or probability (RTDC/LOCL) falls outside the IMM CI.

For TME, it can be observed that the mean values obtained using MEDPRAT V1.0 and V2.0 are almost always within the IMM CI. There are only five exceptions to this, and all are in the MEDPRAT V2.0 runs in the untreated paradigm for long mission durations (>913 days) with six crew members, where this elevated TME in MEDPRAT V2.0 is to be expected given assumption 2, where IMM and MEDPRAT V1.0 in the untreated paradigm remove the crew member once RTDC'd, but MEDPRAT V2.0 keeps these crew members in to reflect deep space assumptions. It should also be noted that the

untreated paradigms with IMM and MEDPRAT V1.0 often have lower TME than the limited and fully treated paradigm simulations. This outcome is contrary to initial expectations; however, it is explained by the removal of RTDC'd crew from the mission in both IMM and MEDPRAT V1.0, thereby preventing them from contracting additional medical conditions. Thus, untreated paradigm simulations for IMM and MEDPRAT V1.0 tend to report fewer TME than their corresponding limited and fully treated runs. Additionally, across all scenarios, it is noted that longer mission duration equates to higher TME—an expected result, given that longer time in the mission leaves more time for astronauts to encounter various medical events. Scenarios S–387 and S–412 best illustrate this phenomenon where the number of medical events is most closely associated with the total mission duration (i.e., for S–387, the 913-day mission has a greater TME than the 180-day, which in turn has greater TME than the 42-day mission).

For CHI, it is noted that the mean values obtained by MEDPRAT V1.0 and V2.0 are within the IMM CIs across all scenarios, DRMs, and treatment paradigms. As for trends in the data, it can be seen that the untreated means are less than the limited and fully treated paradigms across all scenarios, DRMs, and models. Furthermore, the limited treatment paradigm CHI values are less than or equal to those of the fully treated paradigm runs. These observations are to be anticipated given that a higher CHI indicates a healthier crew overall (the only mission-level metric where the greater the number, the better the health outcome for the crew). Moreover, the prevailing trend in almost all cases is that MEDPRAT V2.0 reports higher CHI than MEDPRAT V1.0, which in turn reports higher CHI than IMM. This is the order for all runs save for those in the untreated paradigm, where IMM reports higher CHI than MEDPRAT V1.0 in half of the runs—although MEDPRAT V2.0 still reports the highest of the three models in all cases. This finding of slightly lower CHI in IMM is in accordance with the fact that in both versions of MEDPRAT, RTDC'd crew will incur 100 percent QTL from the point the RTDC occurs until the end of the mission, resulting in elevated QTL and lower CHI compared to IMM. It should be noted though that the CHIs are very similar across all models, as evidenced by all the mean values from MEDPRAT V1.0 and V2.0 falling within the IMM CIs across all scenarios, DRMs, and treatment paradigms.

Regarding EVAC/RTDC and LOCL, it was observed that, as expected, the untreated EVAC/RTDC and LOCL probabilities of at least one occurrence per trial are always greater than the limited and fully treated paradigms across all scenarios, DRMs, and models. In turn, the limited treatment paradigm EVAC/RTDC and LOCL values are in almost all cases greater than the fully treated paradigm, as expected. The only exceptions to these are very minimal differences (being on the order of 10^{-2} or lower) and only occur in short missions of less than or equal to 182.625 days. It was noted that the general prevailing trend for both RTDC and LOCL that MEDPRAT V2.0 reports higher than IMM, which in turn reports higher than MEDPRAT V1.0. Notably, MEDPRAT V1.0 only reports the highest of the three models three times across all SRs and treatment paradigms. It nearly always reports the lowest RTDC and LOCL of the three models. This is to be expected given assumption 1.2, where MEDPRAT V1.0 only reports the first occurrence of either RTDC or LOCL, IMM reports both, and MEDPRAT V2.0 keeps the crew members in the simulation, where they can contract another RTDC or LOCL. It is therefore expected that MEDPRAT V1.0 reports the lowest, i.e., only the first occurrence of RTDC or LOCL. Note that the effects of keeping crew members in the simulation in MEDPRAT V2.0 (assumption 2) will not affect the RTDC or LOCL figures here since the probability considers only that first occurrence towards the calculation. It can be observed that the probabilities for both MEDPRAT V1.0 and V2.0 generally fall outside the IMM CIs. However, these minor discrepancies are consistent with the differences in assumptions and model implementations, and these discrepancies are consistently minimal. For instance, the probability for DRM1 in the untreated paradigm in S–386 is 9.98×10^{-1}, with a CI ranging from 9.98×10^{-1} to 9.99×10^{-1}, while MEDPRAT V1.0 reports 9.96×10^{-1} and

MEDPRAT V2.0 reports 9.97×10^{-1}. Additionally, it is important to consider assumption 3, which indicates that very rare events, such as LOCL, can result in more variable outcomes.

3.2.1 S–386: Risk of Appendicitis and Cholecystitis Versus Risk of SBO Following Prophylactic Surgery (Table X)

TABLE X.—TME, CHI, EVAC/RTDC, AND LOCL FOR IMM, MEDPRAT V1.0, AND MEDPRAT V2.0 WITH THEIR RESPECTIVE 95 PERCENT CI FOR LIMITED, FULLY TREATED, AND UNTREATED PARADIGMS ACROSS ALL DRMS FOR S–386

SR	DRM	Treatment paradigm	Model	TME	CHI	EVAC/RTDC	LOCL
S-386	DRM1	Limited	IMM	513.77 [420.00, 578.00]	72.77 [59.20, 82.58]	5.34×10^{-1} [5.31×10^{-1}, 5.38×10^{-1}]	2.49×10^{-2} [2.40×10^{-2}, 2.59×10^{-2}]
			MEDPRAT V1.0	507.17 [415.00, 566.00]	73.24 [59.78, 82.84]	**5.19×10^{-1} [5.18×10^{-1}, 5.21×10^{-1}]**	**1.67×10^{-2} [1.62×10^{-2}, 1.72×10^{-2}]**
			MEDPRAT V2.0	528.33 [482.00, 573.00]	75.06 [64.22, 83.20]	**5.03×10^{-1} [5.01×10^{-1}, 5.05×10^{-1}]**	**2.61×10^{-2} [2.55×10^{-2}, 2.66×10^{-2}]**
		Fully treated	IMM	527.80 [447.00, 583.00]	87.40 [73.44, 94.52]	1.57×10^{-1} [1.54×10^{-1}, 1.59×10^{-1}]	2.41×10^{-2} [2.32×10^{-2}, 2.51×10^{-2}]
			MEDPRAT V1.0	520.82 [441.00, 571.00]	87.76 [73.85, 94.76]	**1.46×10^{-1} [1.45×10^{-1}, 1.48×10^{-1}]**	**1.52×10^{-2} [1.48×10^{-2}, 1.57×10^{-2}]**
			MEDPRAT V2.0	528.35 [482.00, 573.00]	88.48 [77.06, 94.71]	1.58×10^{-1} [1.57×10^{-1}, 1.60×10^{-1}]	2.42×10^{-2} [2.37×10^{-2}, 2.48×10^{-2}]
		Untreated	IMM	326.76 [180.00, 477.00]	18.19 [12.17, 23.83]	9.98×10^{-1} [9.98×10^{-1}, 9.99×10^{-1}]	7.08×10^{-2} [6.92×10^{-2}, 7.23×10^{-2}]
			MEDPRAT V1.0	339.44 [187.00, 487.00]	18.34 [12.27, 23.92]	**9.96×10^{-1} [9.96×10^{-1}, 9.97×10^{-1}]**	**4.54×10^{-2} [4.46×10^{-2}, 4.61×10^{-2}]**
			MEDPRAT V2.0	**524.38 [457.00, 572.00]**	20.87 [16.62, 25.26]	**9.97×10^{-1} [9.97×10^{-1}, 9.97×10^{-1}]**	**1.10×10^{-1} [1.09×10^{-1}, 1.11×10^{-1}]**
	DRM2	Limited	IMM	513.28 [418.00, 577.00]	72.71 [59.14, 82.59]	5.41×10^{-1} [5.37×10^{-1}, 5.44×10^{-1}]	2.32×10^{-2} [2.23×10^{-2}, 2.42×10^{-2}]
			MEDPRAT V1.0	506.73 [415.00, 565.00]	73.19 [59.71, 82.81]	**5.24×10^{-1} [5.22×10^{-1}, 5.26×10^{-1}]**	**1.47×10^{-2} [1.43×10^{-2}, 1.52×10^{-2}]**
			MEDPRAT V2.0	528.30 [482.00, 573.00]	75.05 [64.20, 83.19]	**5.09×10^{-1} [5.07×10^{-1}, 5.10×10^{-1}]**	**2.45×10^{-2} [2.40×10^{-2}, 2.51×10^{-2}]**
		Fully treated	IMM	527.18 [443.00, 584.00]	87.32 [73.18, 94.52]	1.66×10^{-1} [1.64×10^{-1}, 1.68×10^{-1}]	2.29×10^{-2} [2.21×10^{-2}, 2.39×10^{-2}]
			MEDPRAT V1.0	520.16 [439.00, 571.00]	87.66 [73.45, 94.76]	**1.57×10^{-1} [1.55×10^{-1}, 1.58×10^{-1}]**	**1.42×10^{-2} [1.37×10^{-2}, 1.46×10^{-2}]**
			MEDPRAT V2.0	528.26 [482.00, 573.00]	88.44 [77.02, 94.73]	1.68×10^{-1} [1.67×10^{-1}, 1.69×10^{-1}]	2.33×10^{-2} [2.28×10^{-2}, 2.39×10^{-2}]
		Untreated	IMM	326.64 [180.00, 476.00]	18.15 [12.12, 23.77]	9.98×10^{-1} [9.98×10^{-1}, 9.98×10^{-1}]	6.82×10^{-2} [6.67×10^{-2}, 7.00×10^{-2}]
			MEDPRAT V1.0	339.21 [187.00, 487.00]	18.32 [12.22, 23.93]	**9.96×10^{-1} [9.96×10^{-1}, 9.96×10^{-1}]**	**3.89×10^{-2} [3.83×10^{-2}, 3.96×10^{-2}]**
			MEDPRAT V2.0	**524.52 [459.00, 572.00]**	20.85 [16.59, 25.26]	**9.97×10^{-1} [9.97×10^{-1}, 9.97×10^{-1}]**	**1.04×10^{-1} [1.03×10^{-1}, 1.06×10^{-1}]**
	DRM3	Limited	IMM	513.47 [419.00, 577.00]	72.71 [59.16, 82.58]	5.37×10^{-1} [5.34×10^{-1}, 5.40×10^{-1}]	2.48×10^{-2} [2.39×10^{-2}, 2.57×10^{-2}]
			MEDPRAT V1.0	506.87 [415.00, 565.00]	73.21 [59.63, 82.86]	**5.21×10^{-1} [5.19×10^{-1}, 5.23×10^{-1}]**	**1.66×10^{-2} [1.62×10^{-2}, 1.71×10^{-2}]**
			MEDPRAT V2.0	528.17 [481.00, 573.00]	75.04 [64.12, 83.18]	**5.06×10^{-1} [5.04×10^{-1}, 5.08×10^{-1}]**	**2.60×10^{-2} [2.54×10^{-2}, 2.66×10^{-2}]**
		Fully treated	IMM	527.40 [444.00, 584.00]	87.31 [73.20, 94.52]	1.61×10^{-1} [1.59×10^{-1}, 1.64×10^{-1}]	2.38×10^{-2} [2.30×10^{-2}, 2.48×10^{-2}]
			MEDPRAT V1.0	520.37 [440.00, 571.00]	87.72 [73.59, 94.76]	**1.50×10^{-1} [1.49×10^{-1}, 1.51×10^{-1}]**	**1.51×10^{-2} [1.47×10^{-2}, 1.56×10^{-2}]**

			MEDPRAT V2.0	528.17 [481.00, 573.00]	88.46 [76.96, 94.74]	1.62×10^{-1} [1.61×10^{-1}, 1.63×10^{-1}]	2.40×10^{-2} [2.35×10^{-2}, 2.46×10^{-2}]
		Untreated	IMM	326.85 [180.00, 477.00]	18.15 [12.10, 23.78]	9.98×10^{-1} [9.98×10^{-1}, 9.98×10^{-1}]	7.13×10^{-2} [6.99×10^{-2}, 7.30×10^{-2}]
			MEDPRAT V1.0	339.15 [187.00, 488.00]	18.31 [12.24, 23.89]	**9.96×10^{-1} [9.96×10^{-1}, 9.97×10^{-1}]**	**4.33×10^{-2} [4.26×10^{-2}, 4.41×10^{-2}]**
			MEDPRAT V2.0	**524.32 [457.00, 572.00]**	20.85 [16.57, 25.25]	**9.97×10^{-1} [9.97×10^{-1}, 9.97×10^{-1}]**	**1.08×10^{-1} [1.07×10^{-1}, 1.09×10^{-1}]**
	DRM4	Limited	IMM	513.10 [418.00, 577.00]	72.69 [59.20, 82.61]	5.41×10^{-1} [5.38×10^{-1}, 5.45×10^{-1}]	2.34×10^{-2} [2.25×10^{-2}, 2.43×10^{-2}]
			MEDPRAT V1.0	506.39 [414.00, 565.00]	73.16 [59.63, 82.86]	**5.27×10^{-1} [5.26×10^{-1}, 5.29×10^{-1}]**	**1.47×10^{-2} [1.43×10^{-2}, 1.51×10^{-2}]**
			MEDPRAT V2.0	528.20 [482.00, 573.00]	75.04 [64.19, 83.16]	**5.12×10^{-1} [5.10×10^{-1}, 5.14×10^{-1}]**	**2.48×10^{-2} [2.43×10^{-2}, 2.53×10^{-2}]**
		Fully treated	IMM	527.00 [443.00, 584.00]	87.27 [73.04, 94.51]	1.71×10^{-1} [1.68×10^{-1}, 1.73×10^{-1}]	2.26×10^{-2} [2.17×10^{-2}, 2.36×10^{-2}]
			MEDPRAT V1.0	519.84 [438.00, 571.00]	87.64 [73.39, 94.76]	**1.62×10^{-1} [1.60×10^{-1}, 1.63×10^{-1}]**	**1.40×10^{-2} [1.35×10^{-2}, 1.44×10^{-2}]**
			MEDPRAT V2.0	528.20 [482.00, 573.00]	88.46 [77.01, 94.74]	1.71×10^{-1} [1.70×10^{-1}, 1.72×10^{-1}]	2.33×10^{-2} [2.28×10^{-2}, 2.39×10^{-2}]
		Untreated	IMM	326.97 [180.00, 477.50]	18.16 [12.14, 23.79]	9.98×10^{-1} [9.98×10^{-1}, 9.98×10^{-1}]	6.99×10^{-2} [6.86×10^{-2}, 7.16×10^{-2}]
			MEDPRAT V1.0	339.17 [188.00, 487.00]	18.31 [12.23, 23.91]	**9.96×10^{-1} [9.96×10^{-1}, 9.97×10^{-1}]**	**3.92×10^{-2} [3.85×10^{-2}, 3.99×10^{-2}]**
			MEDPRAT V2.0	**524.39 [458.00, 572.00]**	20.85 [16.58, 25.23]	**9.97×10^{-1} [9.97×10^{-1}, 9.97×10^{-1}]**	**1.07×10^{-1} [1.05×10^{-1}, 1.08×10^{-1}]**

3.2.2 S–387: Impact of Sex on Medical Outcomes for Deep Space Missions (Table XI)

TABLE XI.—TME, CHI, EVAC/RTDC, AND LOCL FOR IMM, MEDPRAT V1.0, AND MEDPRAT V2.0 WITH THEIR RESPECTIVE 95 PERCENT CI FOR LIMITED, FULLY TREATED, AND UNTREATED PARADIGMS ACROSS ALL DRMS FOR S–387

SR	DRM	Treatment paradigm	Model	TME	CHI	EVAC/RTDC	LOCL
S-387	DRM1	Limited	IMM	25.50 [17.00, 34.00]	97.36 [92.86, 98.99]	1.03×10^{-2} [9.68×10^{-3}, 1.10×10^{-2}]	7.10×10^{-4} [5.60×10^{-4}, 8.90×10^{-4}]
			MEDPRAT V1.0	25.32 [17.00, 34.00]	97.72 [94.00, 99.01]	**4.72×10^{-3} [4.47×10^{-3}, 4.95×10^{-3}]**	**5.23×10^{-4} [4.40×10^{-4}, 6.07×10^{-4}]**
			MEDPRAT V2.0	25.39 [17.00, 34.00]	97.74 [94.10, 99.01]	**1.12×10^{-2} [1.08×10^{-2}, 1.16×10^{-2}]**	6.87×10^{-4} [5.90×10^{-4}, 7.80×10^{-4}]
		Fully treated	IMM	25.50 [17.00, 34.00]	97.35 [92.81, 98.99]	1.01×10^{-2} [9.51×10^{-3}, 1.08×10^{-2}]	7.00×10^{-4} [5.50×10^{-4}, 8.80×10^{-4}]
			MEDPRAT V1.0	25.32 [17.00, 34.00]	97.72 [93.97, 99.01]	**4.68×10^{-3} [4.43×10^{-3}, 4.92×10^{-3}]**	**4.33×10^{-4} [3.57×10^{-4}, 5.03×10^{-4}]**
			MEDPRAT V2.0	25.39 [17.00, 34.00]	97.74 [94.10, 99.01]	**1.15×10^{-2} [1.11×10^{-2}, 1.19×10^{-2}]**	7.03×10^{-4} [6.07×10^{-4}, 7.97×10^{-4}]
		Untreated	IMM	24.97 [17.00, 34.00]	86.11 [65.19, 94.77]	2.03×10^{-1} [2.00×10^{-1}, 2.05×10^{-1}]	3.02×10^{-3} [2.70×10^{-3}, 3.41×10^{-3}]
			MEDPRAT V1.0	24.78 [17.00, 34.00]	85.51 [64.63, 94.43]	**1.82×10^{-1} [1.80×10^{-1}, 1.83×10^{-1}]**	**2.22×10^{-3} [2.03×10^{-3}, 2.37×10^{-3}]**
			MEDPRAT V2.0	25.40 [17.00, 34.00]	87.86 [78.58, 94.47]	2.05×10^{-1} [2.03×10^{-1}, 2.06×10^{-1}]	**3.42×10^{-3} [3.23×10^{-3}, 3.63×10^{-3}]**
	DRM2	Limited	IMM	70.15 [55.00, 86.00]	94.99 [81.10, 98.81]	3.65×10^{-2} [3.52×10^{-2}, 3.77×10^{-2}]	3.29×10^{-3} [2.96×10^{-3}, 3.68×10^{-3}]
			MEDPRAT V1.0	69.40 [54.00, 85.00]	95.22 [81.33, 98.86]	**3.27×10^{-2} [3.20×10^{-2}, 3.33×10^{-2}]**	**2.10×10^{-3} [1.92×10^{-3}, 2.27×10^{-3}]**
			MEDPRAT V2.0	69.81 [55.00, 86.00]	95.39 [83.84, 98.85]	**3.78×10^{-2} [3.71×10^{-2}, 3.85×10^{-2}]**	3.19×10^{-3} [2.99×10^{-3}, 3.38×10^{-3}]
		Fully treated	IMM	70.16 [55.00, 86.00]	95.01 [81.25, 98.82]	3.28×10^{-2} [3.17×10^{-2}, 3.41×10^{-2}]	3.26×10^{-3} [2.91×10^{-3}, 3.62×10^{-3}]
			MEDPRAT V1.0	69.46 [54.00, 85.00]	95.26 [81.42, 98.87]	**2.98×10^{-2} [2.92×10^{-2}, 3.04×10^{-2}]**	**2.01×10^{-3} [1.84×10^{-3}, 2.16×10^{-3}]**
			MEDPRAT V2.0	69.79 [55.00, 86.00]	95.41 [83.91, 98.85]	**3.61×10^{-2} [3.54×10^{-2}, 3.68×10^{-2}]**	3.19×10^{-3} [3.00×10^{-3}, 3.38×10^{-3}]
		Untreated	IMM	65.10 [44.00, 84.00]	60.07 [40.01, 74.06]	5.13×10^{-1} [5.10×10^{-1}, 5.16×10^{-1}]	1.34×10^{-2} [1.28×10^{-2}, 1.41×10^{-2}]
			MEDPRAT V1.0	64.50 [44.00, 83.00]	59.94 [38.92, 73.61]	**4.95×10^{-1} [4.93×10^{-1}, 4.96×10^{-1}]**	**8.63×10^{-3} [8.31×10^{-3}, 8.95×10^{-3}]**
			MEDPRAT V2.0	69.71 [55.00, 86.00]	63.65 [50.83, 74.04]	**5.16×10^{-1} [5.15×10^{-1}, 5.18×10^{-1}]**	**1.49×10^{-2} [1.45×10^{-2}, 1.53×10^{-2}]**
	DRM3	Limited	IMM	290.96 [229.00, 333.00]	80.87 [63.03, 91.34]	2.95×10^{-1} [2.93×10^{-1}, 2.98×10^{-1}]	1.65×10^{-2} [1.56×10^{-2}, 1.72×10^{-2}]
			MEDPRAT V1.0	287.25 [227.00, 327.00]	81.26 [63.49, 91.50]	**2.92×10^{-1} [2.90×10^{-1}, 2.93×10^{-1}]**	**1.02×10^{-2} [9.86×10^{-3}, 1.05×10^{-2}]**
			MEDPRAT V2.0	296.05 [261.00, 330.00]	83.83 [69.40, 92.46]	**2.35×10^{-1} [2.33×10^{-1}, 2.36×10^{-1}]**	**1.77×10^{-2} [1.72×10^{-2}, 1.82×10^{-2}]**
		Fully treated	IMM	295.68 [237.00, 335.00]	89.01 [70.38, 96.79]	1.12×10^{-1} [1.10×10^{-1}, 1.14×10^{-1}]	1.59×10^{-2} [1.52×10^{-2}, 1.67×10^{-2}]
			MEDPRAT V1.0	291.93 [235.00, 329.00]	89.25 [70.65, 96.91]	**1.04×10^{-1} [1.03×10^{-1}, 1.06×10^{-1}]**	**1.01×10^{-2} [9.77×10^{-3}, 1.05×10^{-2}]**
			MEDPRAT V2.0	296.03 [262.00, 330.00]	90.03 [75.23, 96.86]	**1.31×10^{-1} [1.30×10^{-1}, 1.32×10^{-1}]**	1.62×10^{-2} [1.58×10^{-2}, 1.67×10^{-2}]
		Untreated	IMM	208.45 [102.00, 304.00]	19.27 [11.32, 26.58]	9.60×10^{-1} [9.59×10^{-1}, 9.61×10^{-1}]	4.67×10^{-2} [4.53×10^{-2}, 4.80×10^{-2}]
			MEDPRAT V1.0	206.16 [101.00, 299.00]	19.33 [11.28, 26.63]	**9.57×10^{-1} [9.56×10^{-1}, 9.58×10^{-1}]**	**3.21×10^{-2} [3.16×10^{-2}, 3.28×10^{-2}]**
			MEDPRAT V2.0	294.04 [248.00, 329.00]	22.02 [16.43, 27.82]	**9.62×10^{-1} [9.61×10^{-1}, 9.63×10^{-1}]**	**7.14×10^{-2} [7.05×10^{-2}, 7.24×10^{-2}]**
	DRM4	Limited	IMM	26.12 [18.00, 35.00]	97.25 [92.73, 98.95]	9.90×10^{-3} [9.33×10^{-3}, 1.06×10^{-2}]	7.20×10^{-4} [5.70×10^{-4}, 9.00×10^{-4}]
			MEDPRAT V1.0	25.93 [18.00, 35.00]	97.64 [93.93, 98.97]	**4.77×10^{-3} [4.53×10^{-3}, 5.03×10^{-3}]**	**4.03×10^{-4} [3.33×10^{-4}, 4.73×10^{-4}]**
			MEDPRAT V2.0	26.03 [18.00, 35.00]	97.66 [94.02, 98.96]	**1.16×10^{-2} [1.12×10^{-2}, 1.20×10^{-2}]**	7.73×10^{-4} [6.77×10^{-4}, 8.70×10^{-4}]
		Fully treated	IMM	26.12 [18.00, 35.00]	97.25 [92.68, 98.95]	9.64×10^{-3} [9.07×10^{-3}, 1.03×10^{-2}]	7.20×10^{-4} [5.60×10^{-4}, 9.00×10^{-4}]
			MEDPRAT V1.0	25.94 [18.00, 35.00]	97.64 [93.91, 98.97]	**4.64×10^{-3} [4.39×10^{-3}, 4.88×10^{-3}]**	**4.93×10^{-4} [4.10×10^{-4}, 5.73×10^{-4}]**
			MEDPRAT V2.0	26.04 [18.00, 35.00]	97.66 [93.99, 98.96]	**1.12×10^{-2} [1.08×10^{-2}, 1.15×10^{-2}]**	7.70×10^{-4} [6.73×10^{-4}, 8.63×10^{-4}]
		Untreated	IMM	25.33 [17.00, 35.00]	84.65 [62.56, 94.54]	2.54×10^{-1} [2.51×10^{-1}, 2.57×10^{-1}]	3.50×10^{-3} [3.12×10^{-3}, 3.88×10^{-3}]
			MEDPRAT V1.0	25.14 [17.00, 34.00]	84.06 [61.97, 94.14]	**2.30×10^{-1} [2.29×10^{-1}, 2.32×10^{-1}]**	**2.00×10^{-3} [1.84×10^{-3}, 2.16×10^{-3}]**
			MEDPRAT V2.0	26.03 [18.00, 35.00]	87.58 [78.32, 94.25]	**2.58×10^{-1} [2.56×10^{-1}, 2.59×10^{-1}]**	3.25×10^{-3} [3.03×10^{-3}, 3.43×10^{-3}]
	DRM5	Limited	IMM	72.02 [56.00, 89.00]	94.83 [81.06, 98.72]	3.88×10^{-2} [3.77×10^{-2}, 4.01×10^{-2}]	2.91×10^{-3} [2.59×10^{-3}, 3.26×10^{-3}]
			MEDPRAT V1.0	71.30 [56.00, 87.00]	95.07 [81.13, 98.78]	**3.49×10^{-2} [3.43×10^{-2}, 3.55×10^{-2}]**	**2.01×10^{-3} [1.85×10^{-3}, 2.16×10^{-3}]**
			MEDPRAT V2.0	71.67 [56.00, 88.00]	95.28 [83.79, 98.77]	**3.75×10^{-2} [3.68×10^{-2}, 3.82×10^{-2}]**	3.21×10^{-3} [2.99×10^{-3}, 3.39×10^{-3}]
		Fully treated	IMM	72.05 [56.00, 89.00]	94.89 [81.27, 98.73]	3.12×10^{-2} [3.01×10^{-2}, 3.23×10^{-2}]	2.92×10^{-3} [2.59×10^{-3}, 3.27×10^{-3}]
			MEDPRAT V1.0	71.33 [56.00, 87.00]	95.14 [81.38, 98.79]	**2.87×10^{-2} [2.81×10^{-2}, 2.92×10^{-2}]**	**1.98×10^{-3} [1.82×10^{-3}, 2.16×10^{-3}]**
			MEDPRAT V2.0	71.64 [56.00, 88.00]	95.30 [83.77, 98.77]	**3.59×10^{-2} [3.53×10^{-2}, 3.66×10^{-2}]**	3.11×10^{-3} [2.93×10^{-3}, 3.32×10^{-3}]

TABLE XI.—TME, CHI, EVAC/RTDC, AND LOCL FOR IMM, MEDPRAT V1.0, AND MEDPRAT V2.0 WITH THEIR RESPECTIVE 95 PERCENT CI FOR LIMITED, FULLY TREATED, AND UNTREATED PARADIGMS ACROSS ALL DRMS FOR S–387

SR	DRM	Treatment paradigm	Model	TME	CHI	EVAC/RTDC	LOCL
S-387		Untreated	IMM	65.87 [44.00, 86.00]	58.57 [37.05, 73.37]	5.54×10^{-1} [5.51×10^{-1}, 5.57×10^{-1}]	1.25×10^{-2} [1.18×10^{-2}, 1.31×10^{-2}]
			MEDPRAT V1.0	65.22 [43.00, 84.00]	58.37 [35.82, 72.72]	**5.37×10^{-1} [5.35×10^{-1}, 5.39×10^{-1}]**	**8.68×10^{-3} [8.38×10^{-3}, 8.98×10^{-3}]**
			MEDPRAT V2.0	71.59 [56.00, 88.00]	63.05 [50.32, 73.38]	**5.58×10^{-1} [5.56×10^{-1}, 5.60×10^{-1}]**	**1.49×10^{-2} [1.45×10^{-2}, 1.53×10^{-2}]**
	DRM6	Limited	IMM	296.75 [231.00, 341.00]	78.57 [60.34, 89.67]	3.50×10^{-1} [3.47×10^{-1}, 3.53×10^{-1}]	1.57×10^{-2} [1.49×10^{-2}, 1.64×10^{-2}]
			MEDPRAT V1.0	292.88 [229.00, 335.00]	78.86 [60.82, 89.67]	3.48×10^{-1} [3.46×10^{-1}, 3.50×10^{-1}]	**1.03×10^{-2} [9.92×10^{-3}, 1.06×10^{-2}]**
			MEDPRAT V2.0	304.29 [269.00, 339.00]	82.30 [68.05, 91.13]	**2.38×10^{-1} [2.36×10^{-1}, 2.39×10^{-1}]**	**1.80×10^{-2} [1.75×10^{-2}, 1.85×10^{-2}]**
		Fully treated	IMM	304.06 [244.00, 344.00]	88.70 [70.20, 96.49]	1.10×10^{-1} [1.08×10^{-1}, 1.12×10^{-1}]	1.53×10^{-2} [1.45×10^{-2}, 1.60×10^{-2}]
			MEDPRAT V1.0	300.19 [241.00, 338.00]	88.95 [70.49, 96.64]	**1.02×10^{-1} [1.01×10^{-1}, 1.03×10^{-1}]**	**9.90×10^{-3} [9.56×10^{-3}, 1.02×10^{-2}]**
			MEDPRAT V2.0	304.41 [270.00, 339.00]	89.72 [75.04, 96.62]	**1.29×10^{-1} [1.28×10^{-1}, 1.30×10^{-1}]**	1.52×10^{-2} [1.47×10^{-2}, 1.56×10^{-2}]
		Untreated	IMM	208.48 [97.00, 309.00]	18.51 [10.39, 25.83]	9.68×10^{-1} [9.67×10^{-1}, 9.69×10^{-1}]	4.56×10^{-2} [4.43×10^{-2}, 4.70×10^{-2}]
			MEDPRAT V1.0	205.84 [97.00, 305.00]	18.52 [10.33, 25.83]	**9.65×10^{-1} [9.64×10^{-1}, 9.65×10^{-1}]**	**3.10×10^{-2} [3.04×10^{-2}, 3.17×10^{-2}]**
			MEDPRAT V2.0	302.24 [256.00, 338.00]	21.50 [16.06, 27.17]	**9.69×10^{-1} [9.69×10^{-1}, 9.70×10^{-1}]**	**7.15×10^{-2} [7.06×10^{-2}, 7.25×10^{-2}]**
	DRM7	Limited	IMM	24.85 [17.00, 34.00]	97.47 [93.08, 99.03]	1.07×10^{-2} [1.01×10^{-2}, 1.14×10^{-2}]	7.50×10^{-4} [6.00×10^{-4}, 9.45×10^{-4}]
			MEDPRAT V1.0	24.71 [17.00, 33.00]	97.80 [94.14, 99.05]	**4.95×10^{-3} [4.68×10^{-3}, 5.20×10^{-3}]**	**4.97×10^{-4} [4.17×10^{-4}, 5.73×10^{-4}]**
			MEDPRAT V2.0	24.79 [17.00, 33.00]	97.82 [94.23, 99.04]	**1.18×10^{-2} [1.14×10^{-2}, 1.21×10^{-2}]**	7.43×10^{-4} [6.40×10^{-4}, 8.40×10^{-4}]
		Fully treated	IMM	24.85 [17.00, 34.00]	97.46 [93.05, 99.03]	1.06×10^{-2} [9.96×10^{-3}, 1.12×10^{-2}]	7.60×10^{-4} [6.10×10^{-4}, 9.60×10^{-4}]
			MEDPRAT V1.0	24.70 [17.00, 33.00]	97.80 [94.10, 99.05]	**4.73×10^{-3} [4.49×10^{-3}, 4.96×10^{-3}]**	**4.60×10^{-4} [3.87×10^{-4}, 5.43×10^{-4}]**
			MEDPRAT V2.0	24.79 [17.00, 33.00]	97.82 [94.21, 99.05]	**1.15×10^{-2} [1.11×10^{-2}, 1.18×10^{-2}]**	7.40×10^{-4} [6.33×10^{-4}, 8.27×10^{-4}]
		Untreated	IMM	24.59 [17.00, 33.00]	87.58 [69.19, 95.06]	1.50×10^{-1} [1.47×10^{-1}, 1.52×10^{-1}]	3.45×10^{-3} [3.11×10^{-3}, 3.83×10^{-3}]
			MEDPRAT V1.0	24.45 [16.00, 33.00]	86.99 [68.72, 94.69]	**1.29×10^{-1} [1.28×10^{-1}, 1.30×10^{-1}]**	**2.04×10^{-3} [1.87×10^{-3}, 2.20×10^{-3}]**
			MEDPRAT V2.0	24.80 [17.00, 33.00]	88.14 [78.85, 94.69]	1.52×10^{-1} [1.51×10^{-1}, 1.53×10^{-1}]	3.39×10^{-3} [3.20×10^{-3}, 3.61×10^{-3}]
	DRM8	Limited	IMM	68.25 [53.00, 84.00]	95.13 [81.23, 98.89]	3.54×10^{-2} [3.43×10^{-2}, 3.65×10^{-2}]	3.61×10^{-3} [3.23×10^{-3}, 3.95×10^{-3}]
			MEDPRAT V1.0	67.57 [52.00, 83.00]	95.33 [81.20, 98.94]	**3.27×10^{-2} [3.20×10^{-2}, 3.33×10^{-2}]**	**2.13×10^{-3} [1.96×10^{-3}, 2.30×10^{-3}]**
			MEDPRAT V2.0	67.92 [53.00, 84.00]	95.52 [84.00, 98.92]	**3.80×10^{-2} [3.74×10^{-2}, 3.87×10^{-2}]**	3.30×10^{-3} [3.09×10^{-3}, 3.51×10^{-3}]
		Fully treated	IMM	68.26 [53.00, 84.00]	95.13 [81.30, 98.89]	3.34×10^{-2} [3.23×10^{-2}, 3.45×10^{-2}]	3.58×10^{-3} [3.24×10^{-3}, 3.93×10^{-3}]
			MEDPRAT V1.0	67.58 [53.00, 83.00]	95.38 [81.49, 98.95]	**3.02×10^{-2} [2.95×10^{-2}, 3.08×10^{-2}]**	**2.06×10^{-3} [1.91×10^{-3}, 2.21×10^{-3}]**
			MEDPRAT V2.0	67.92 [53.00, 84.00]	95.53 [84.04, 98.92]	**3.66×10^{-2} [3.59×10^{-2}, 3.72×10^{-2}]**	3.30×10^{-3} [3.08×10^{-3}, 3.51×10^{-3}]
		Untreated	IMM	64.35 [45.00, 82.00]	61.62 [43.15, 74.83]	4.68×10^{-1} [4.64×10^{-1}, 4.70×10^{-1}]	1.41×10^{-2} [1.34×10^{-2}, 1.48×10^{-2}]
			MEDPRAT V1.0	63.75 [45.00, 81.00]	61.44 [42.00, 74.42]	**4.50×10^{-1} [4.48×10^{-1}, 4.52×10^{-1}]**	**8.50×10^{-3} [8.17×10^{-3}, 8.84×10^{-3}]**
			MEDPRAT V2.0	67.86 [53.00, 83.00]	64.26 [51.39, 74.66]	4.69×10^{-1} [4.67×10^{-1}, 4.71×10^{-1}]	1.46×10^{-2} [1.42×10^{-2}, 1.50×10^{-2}]
	DRM9	Limited	IMM	284.95 [227.00, 325.00]	82.55 [65.18, 92.42]	2.28×10^{-1} [2.26×10^{-1}, 2.31×10^{-1}]	1.66×10^{-2} [1.58×10^{-2}, 1.74×10^{-2}]
			MEDPRAT V1.0	281.28 [224.00, 319.00]	82.86 [65.44, 92.58]	**2.20×10^{-1} [2.18×10^{-1}, 2.21×10^{-1}]**	**1.04×10^{-2} [1.01×10^{-2}, 1.08×10^{-2}]**
			MEDPRAT V2.0	287.75 [254.00, 321.00]	84.48 [70.03, 93.03]	**2.31×10^{-1} [2.30×10^{-1}, 2.33×10^{-1}]**	**1.76×10^{-2} [1.71×10^{-2}, 1.81×10^{-2}]**
		Fully treated	IMM	287.28 [231.00, 326.00]	89.33 [70.68, 97.06]	1.16×10^{-1} [1.14×10^{-1}, 1.18×10^{-1}]	1.61×10^{-2} [1.53×10^{-2}, 1.69×10^{-2}]
			MEDPRAT V1.0	283.55 [227.00, 320.00]	89.54 [70.84, 97.16]	**1.09×10^{-1} [1.08×10^{-1}, 1.10×10^{-1}]**	**9.93×10^{-3} [9.58×10^{-3}, 1.03×10^{-2}]**
			MEDPRAT V2.0	287.76 [254.00, 321.00]	90.36 [75.53, 97.12]	**1.34×10^{-1} [1.33×10^{-1}, 1.35×10^{-1}]**	1.67×10^{-2} [1.63×10^{-2}, 1.72×10^{-2}]
		Untreated	IMM	209.07 [107.00, 298.00]	20.10 [12.28, 27.37]	9.50×10^{-1} [9.48×10^{-1}, 9.51×10^{-1}]	5.08×10^{-2} [4.95×10^{-2}, 5.21×10^{-2}]
			MEDPRAT V1.0	206.31 [106.00, 294.00]	20.12 [12.21, 27.41]	**9.47×10^{-1} [9.46×10^{-1}, 9.47×10^{-1}]**	**3.26×10^{-2} [3.19×10^{-2}, 3.32×10^{-2}]**
			MEDPRAT V2.0	285.68 [240.00, 321.00]	22.52 [16.78, 28.47]	**9.53×10^{-1} [9.52×10^{-1}, 9.53×10^{-1}]**	**7.26×10^{-2} [7.16×10^{-2}, 7.35×10^{-2}]**

3.2.3 S–388: Impact of Heroic Medical Care Measures on Subsequent Medical Outcomes (Table XII)

TABLE XII.—TME, CHI, EVAC/RTDC, AND LOCL FOR IMM, MEDPRAT V1.0, AND MEDPRAT V2.0 WITH THEIR RESPECTIVE 95 PERCENT CI FOR LIMITED, FULLY TREATED, AND UNTREATED PARADIGMS ACROSS ALL DRMS FOR S–388

SR	DRM	Treatment paradigm	Model	TME	CHI	EVAC/RTDC	LOCL
S-388	DRM1	Limited	IMM	180.32 [147.00, 209.00]	90.28 [72.70, 97.24]	1.33×10^{-1} [1.31×10^{-1}, 1.35×10^{-1}]	9.45×10^{-3} [8.84×10^{-3}, 1.00×10^{-2}]
			MEDPRAT V1.0	178.07 [145.00, 206.00]	90.62 [73.00, 97.39]	**1.24×10^{-1} [1.23×10^{-1}, 1.26×10^{-1}]**	**6.11×10^{-3} [5.83×10^{-3}, 6.38×10^{-3}]**
			MEDPRAT V2.0	180.45 [155.00, 207.00]	91.40 [77.41, 97.36]	**1.30×10^{-1} [1.28×10^{-1}, 1.31×10^{-1}]**	9.71×10^{-3} [9.36×10^{-3}, 1.01×10^{-2}]
		Fully treated	IMM	181.11 [149.00, 210.00]	91.88 [74.17, 97.96]	7.28×10^{-2} [7.12×10^{-2}, 7.43×10^{-2}]	9.31×10^{-3} [8.72×10^{-3}, 9.88×10^{-3}]
			MEDPRAT V1.0	178.89 [147.00, 206.00]	92.13 [74.39, 98.06]	**6.69×10^{-2} [6.60×10^{-2}, 6.78×10^{-2}]**	**6.06×10^{-3} [5.79×10^{-3}, 6.31×10^{-3}]**
			MEDPRAT V2.0	180.52 [155.00, 207.00]	92.60 [78.64, 98.03]	**8.37×10^{-2} [8.27×10^{-2}, 8.46×10^{-2}]**	9.66×10^{-3} [9.30×10^{-3}, 1.00×10^{-2}]
		Untreated	IMM	146.22 [84.00, 197.00]	30.86 [18.46, 41.73]	8.57×10^{-1} [8.55×10^{-1}, 8.59×10^{-1}]	3.33×10^{-2} [3.23×10^{-2}, 3.44×10^{-2}]
			MEDPRAT V1.0	144.71 [83.00, 194.00]	30.94 [18.44, 41.85]	**8.48×10^{-1} [8.46×10^{-1}, 8.49×10^{-1}]**	**2.11×10^{-2} [2.06×10^{-2}, 2.17×10^{-2}]**
			MEDPRAT V2.0	179.82 [152.00, 206.00]	34.59 [26.17, 43.11]	8.58×10^{-1} [8.57×10^{-1}, 8.59×10^{-1}]	**4.24×10^{-2} [4.17×10^{-2}, 4.31×10^{-2}]**
	DRM2	Limited	IMM	179.87 [143.00, 210.00]	88.80 [70.47, 96.72]	2.00×10^{-1} [1.98×10^{-1}, 2.02×10^{-1}]	1.39×10^{-2} [1.32×10^{-2}, 1.47×10^{-2}]
			MEDPRAT V1.0	177.60 [142.00, 206.00]	88.96 [70.47, 96.83]	**1.95×10^{-1} [1.94×10^{-1}, 1.96×10^{-1}]**	**9.69×10^{-3} [9.35×10^{-3}, 1.01×10^{-2}]**
			MEDPRAT V2.0	180.49 [155.00, 206.00]	91.40 [77.37, 97.34]	**1.30×10^{-1} [1.28×10^{-1}, 1.31×10^{-1}]**	**9.89×10^{-3} [9.54×10^{-3}, 1.02×10^{-2}]**
		Fully treated	IMM	182.08 [149.00, 211.00]	91.88 [74.18, 97.95]	7.16×10^{-2} [7.02×10^{-2}, 7.34×10^{-2}]	9.16×10^{-3} [8.57×10^{-3}, 9.77×10^{-3}]
			MEDPRAT V1.0	179.82 [148.00, 207.00]	92.12 [74.28, 98.06]	**6.78×10^{-2} [6.69×10^{-2}, 6.86×10^{-2}]**	**5.98×10^{-3} [5.73×10^{-3}, 6.24×10^{-3}]**
			MEDPRAT V2.0	180.52 [155.00, 207.00]	92.61 [78.72, 98.03]	**8.44×10^{-2} [8.34×10^{-2}, 8.54×10^{-2}]**	9.75×10^{-3} [9.40×10^{-3}, 1.01×10^{-2}]
		Untreated	IMM	147.49 [85.00, 198.00]	30.88 [18.53, 41.76]	8.57×10^{-1} [8.55×10^{-1}, 8.59×10^{-1}]	3.25×10^{-2} [3.14×10^{-2}, 3.36×10^{-2}]
			MEDPRAT V1.0	145.72 [84.00, 195.00]	30.94 [18.45, 41.84]	**8.49×10^{-1} [8.47×10^{-1}, 8.50×10^{-1}]**	**2.14×10^{-2} [2.09×10^{-2}, 2.20×10^{-2}]**
			MEDPRAT V2.0	179.80 [152.00, 206.00]	34.60 [26.16, 43.10]	**8.60×10^{-1} [8.59×10^{-1}, 8.61×10^{-1}]**	**4.24×10^{-2} [4.17×10^{-2}, 4.31×10^{-2}]**
	DRM3	Limited	IMM	180.29 [145.00, 210.00]	89.18 [71.49, 96.79]	1.90×10^{-1} [1.88×10^{-1}, 1.93×10^{-1}]	1.31×10^{-2} [1.25×10^{-2}, 1.39×10^{-2}]
			MEDPRAT V1.0	177.98 [144.00, 206.00]	89.38 [71.65, 96.91]	**1.87×10^{-1} [1.86×10^{-1}, 1.89×10^{-1}]**	**8.58×10^{-3} [8.26×10^{-3}, 8.89×10^{-3}]**
			MEDPRAT V2.0	180.47 [155.00, 207.00]	91.41 [77.50, 97.35]	**1.30×10^{-1} [1.28×10^{-1}, 1.31×10^{-1}]**	**9.69×10^{-3} [9.37×10–3, 1.00×10^{-2}]**
		Fully treated	IMM	182.15 [150.00, 211.00]	91.89 [74.27, 97.95]	7.03×10^{-2} [6.86×10^{-2}, 7.18×10^{-2}]	9.17×10^{-3} [8.61×10^{-3}, 9.74×10^{-3}]
			MEDPRAT V1.0	179.80 [147.00, 207.00]	92.09 [74.32, 98.06]	**6.83×10^{-2} [6.74×10^{-2}, 6.92×10^{-2}]**	**5.97×10^{-3} [5.67×10^{-3}, 6.26×10^{-3}]**
			MEDPRAT V2.0	180.46 [155.00, 207.00]	92.61 [78.66, 98.03]	**8.44×10^{-2} [8.34×10^{-2}, 8.53×10^{-2}]**	9.62×10^{-3} [9.27×10^{-3}, 9.98×10^{-3}]
		Untreated	IMM	147.28 [85.00, 198.00]	30.88 [18.53, 41.73]	8.57×10–1 [8.55×10^{-1}, 8.59×10^{-1}]	3.19×10^{-2} [3.08×10^{-2}, 3.29×10^{-2}]
			MEDPRAT V1.0	145.57 [84.00, 195.00]	30.94 [18.45, 41.83]	**8.48×10^{-1} [8.47×10^{-1}, 8.50×10^{-1}]**	**2.09×10^{-2} [2.04×10^{-2}, 2.15×10^{-2}]**
			MEDPRAT V2.0	179.81 [152.00, 206.00]	34.60 [26.20, 43.09]	8.59×10^{-1} [8.58×10^{-1}, 8.60×10^{-1}]	**4.17×10^{-2} [4.10×10–2, 4.24×10–2]**
	DRM4	Limited	IMM	180.86 [147.00, 210.00]	89.73 [72.24, 96.97]	1.73×10^{-1} [1.71×10^{-1}, 1.75×10^{-1}]	1.19×10^{-2} [1.13×10^{-2}, 1.26×10^{-2}]
			MEDPRAT V1.0	178.55 [145.00, 206.00]	89.98 [72.48, 97.10]	**1.68×10^{-1} [1.67×10^{-1}, 1.70×10^{-1}]**	**7.83×10^{-3} [7.54×10^{-3}, 8.16×10^{-3}]**
			MEDPRAT V2.0	180.49 [155.00, 207.00]	91.38 [77.37, 97.35]	**1.30×10^{-1} [1.28×10^{-1}, 1.31×10^{-1}]**	**9.81×10^{-3} [9.48×10^{-3}, 1.02×10^{-2}]**
		Fully treated	IMM	182.09 [149.00, 211.00]	91.87 [74.05, 97.96]	7.29×10^{-2} [7.10×10^{-2}, 7.44×10^{-2}]	9.81×10^{-3} [9.21×10^{-3}, 1.04×10^{-2}]
			MEDPRAT V1.0	179.77 [148.00, 207.00]	92.12 [74.33, 98.06]	**6.81×10^{-2} [6.72×10^{-2}, 6.90×10^{-2}]**	**5.94×10^{-3} [5.68×10^{-3}, 6.24×10^{-3}]**
			MEDPRAT V2.0	180.48 [155.00, 206.00]	92.59 [78.59, 98.03]	**8.29×10^{-2} [8.19×10^{-2}, 8.39×10^{-2}]**	9.62×10^{-3} [9.28×10^{-3}, 9.98×10^{-3}]
		Untreated	IMM	147.19 [84.00, 198.00]	30.90 [18.48, 41.78]	8.57×10^{-1} [8.55×10^{-1}, 8.59×10^{-1}]	3.27×10^{-2} [3.14×10^{-2}, 3.36×10^{-2}]
			MEDPRAT V1.0	145.51 [84.00, 195.00]	30.94 [18.41, 41.83]	**8.49×10^{-1} [8.47×10^{-1}, 8.50×10^{-1}]**	**2.13×10^{-2} [2.08×10^{-2}, 2.19×10^{-2}]**
			MEDPRAT V2.0	179.78 [152.00, 206.00]	34.59 [26.20, 43.07]	8.59×10^{-1} [8.58×10^{-1}, 8.60×10^{-1}]	**4.27×10^{-2} [4.20×10^{-2}, 4.34×10^{-2}]**
	DRM5	Limited	IMM	181.14 [147.00, 210.00]	90.11 [72.56, 97.12]	1.54×10^{-1} [1.52×10^{-1}, 1.56×10^{-1}]	1.09×10^{-2} [1.02×10^{-2}, 1.15×10^{-2}]
			MEDPRAT V1.0	178.98 [146.00, 207.00]	90.45 [72.98, 97.27]	**1.45×10^{-1} [1.44×10^{-1}, 1.47×10^{-1}]**	**6.93×10^{-3} [6.62×10^{-3}, 7.23×10^{-3}]**
			MEDPRAT V2.0	180.50 [155.00, 207.00]	91.39 [77.41, 97.35]	**1.29×10^{-1} [1.28×10^{-1}, 1.30×10^{-1}]**	**9.75×10^{-3} [9.39×10^{-3}, 1.01×10^{-2}]**

TABLE XII.—TME, CHI, EVAC/RTDC, AND LOCL FOR IMM, MEDPRAT V1.0, AND MEDPRAT V2.0 WITH THEIR RESPECTIVE 95 PERCENT CI FOR LIMITED, FULLY TREATED, AND UNTREATED PARADIGMS ACROSS ALL DRMS FOR S–388

SR	DRM	Treatment paradigm	Model	TME	CHI	EVAC/RTDC	LOCL
		Fully treated	IMM	182.03 [149.00, 211.00]	91.86 [74.08, 97.96]	7.36×10^{-2} [7.20×10^{-2}, 7.53×10^{-2}]	9.32×10^{-3} [8.67×10^{-3}, 9.90×10^{-3}]
			MEDPRAT V1.0	179.77 [148.00, 207.00]	92.12 [74.33, 98.06]	**6.78×10^{-2} [6.70×10^{-2}, 6.86×10^{-2}]**	**6.12×10^{-3} [5.84×10^{-3}, 6.38×10^{-3}]**
			MEDPRAT V2.0	180.46 [155.00, 207.00]	92.60 [78.64, 98.02]	**8.42×10^{-2} [8.32×10^{-2}, 8.51×10^{-2}]**	9.68×10^{-3} [9.34×10^{-3}, 1.00×10^{-2}]
		Untreated	IMM	146.97 [84.00, 197.00]	30.86 [18.38, 41.75]	8.58×10^{-1} [8.56×10^{-1}, 8.60×10^{-1}]	3.29×10^{-2} [3.17×10^{-2}, 3.40×10^{-2}]
			MEDPRAT V1.0	145.50 [83.00, 195.00]	30.93 [18.42, 41.85]	**8.48×10^{-1} [8.46×10^{-1}, 8.49×10^{-1}]**	**2.12×10^{-2} [2.07×10^{-2}, 2.17×10^{-2}]**
			MEDPRAT V2.0	179.82 [152.00, 206.00]	34.58 [26.18, 43.06]	**8.60×10^{-1} [8.59×10^{-1}, 8.62×10^{-1}]**	**4.24×10^{-2} [4.16×10^{-2}, 4.31×10^{-2}]**

3.2.4 S–412: Lunar 27.5-Day and 7.5-Day Assessment (Table XIII)

TABLE XIII.—TME, CHI, EVAC/RTDC, AND LOCL FOR IMM, MEDPRAT V1.0, AND MEDPRAT V2. WITH THEIR RESPECTIVE 95 PERCENT CI FOR LIMITED, FULLY TREATED, AND UNTREATED PARADIGMS ACROSS ALL DRMS FOR S–412

SR	DRM	Treatment paradigm	Model	TME	CHI	EVAC/RTDC	LOCL
S-412	7p5day	Limited	IMM	2.65 [0.00, 6.00]	97.57 [88.51, 100.00]	5.50×10^{-4} [4.20×10^{-4}, 7.10×10^{-4}]	6.00×10^{-5} [2.00×10^{-5}, 1.30×10^{-4}]
			MEDPRAT V1.0	2.56 [0.00, 6.00]	98.03 [92.30, 100.00]	**2.27×10^{-4} [1.73×10^{-4}, 2.80×10^{-4}]**	**1.00×10^{-5} [0×10^{0}, 2.00×10^{-5}]**
			MEDPRAT V2.0	2.57 [0.00, 6.00]	98.02 [92.23, 100.00]	4.87×10^{-4} [4.10×10^{-4}, 5.70×10^{-4}]	4.33×10^{-5} [1.67×10^{-5}, 6.33×10^{-5}]
		Fully treated	IMM	2.65 [0.00, 6.00]	97.57 [88.51, 100.00]	5.50×10^{-4} [4.20×10^{-4}, 7.10×10^{-4}]	5.00×10^{-5} [2.00×10^{-5}, 1.10×10^{-4}]
			MEDPRAT V1.0	2.57 [0.00, 6.00]	98.01 [92.25, 100.00]	**2.70×10^{-4} [2.10×10^{-4}, 3.27×10^{-4}]**	2.00×10^{-5} [3.33×10^{-6}, 3.33×10^{-5}]
			MEDPRAT V2.0	2.58 [0.00, 6.00]	98.02 [92.29, 100.00]	4.57×10^{-4} [3.77×10^{-4}, 5.27×10^{-4}]	2.67×10^{-5} [6.67×10^{-6}, 4.33×10^{-5}]
		Untreated	IMM	2.64 [0.00, 6.00]	94.45 [78.65, 100.00]	4.32×10^{-2} [4.18×10^{-2}, 4.44×10^{-2}]	3.90×10^{-4} [2.80×10^{-4}, 5.30×10^{-4}]
			MEDPRAT V1.0	2.55 [0.00, 6.00]	94.52 [81.54, 100.00]	**1.83×10^{-2} [1.79×10^{-2}, 1.88×10^{-2}]**	**9.33×10^{-5} [5.67×10^{-5}, 1.30×10^{-4}]**
			MEDPRAT V2.0	2.58 [0.00, 6.00]	94.70 [82.97, 100.00]	**2.83×10^{-2} [2.78×10^{-2}, 2.89×10^{-2}]**	3.03×10^{-4} [2.40×10^{-4}, 3.63×10^{-4}]
	7p5day_ opt	Limited	IMM	2.65 [0.00, 6.00]	97.63 [89.76, 100.00]	3.71×10^{-3} [3.34×10^{-3}, 4.11×10^{-3}]	1.80×10^{-4} [1.10×10^{-4}, 2.80×10^{-4}]
			MEDPRAT V1.0	2.56 [0.00, 6.00]	97.05 [88.46, 100.00]	**7.33×10^{-3} [7.03×10^{-3}, 7.63×10^{-3}]**	1.17×10^{-4} [7.67×10^{-5}, 1.57×10^{-4}]
			MEDPRAT V2.0	2.58 [0.00, 6.00]	97.87 [91.12, 100.00]	**3.25×10^{-3} [3.06×10^{-3}, 3.45×10^{-3}]**	1.40×10^{-4} [9.67×10^{-5}, 1.83×10^{-4}]
		Fully treated	IMM	2.65 [0.00, 6.00]	97.57 [88.57, 100.00]	4.10×10^{-4} [2.90×10^{-4}, 5.60×10^{-4}]	5.00×10^{-5} [2.00×10^{-5}, 1.10×10^{-4}]
			MEDPRAT V1.0	2.56 [0.00, 6.00]	98.02 [92.29, 100.00]	**2.77×10^{-4} [2.13×10^{-4}, 3.33×10^{-4}]**	5.33×10^{-5} [2.33×10^{-5}, 7.67×10^{-5}]
			MEDPRAT V2.0	2.58 [0.00, 6.00]	98.02 [92.18, 100.00]	4.40×10^{-4} [3.67×10^{-4}, 5.17×10^{-4}]	3.67×10^{-5} [1.33×10^{-5}, 5.67×10^{-5}]
		Untreated	IMM	2.64 [0.00, 6.00]	94.46 [79.08, 100.00]	4.25×10^{-2} [4.14×10^{-2}, 4.38×10^{-2}]	4.50×10^{-4} [3.40×10^{-4}, 6.00×10^{-4}]
			MEDPRAT V1.0	2.56 [0.00, 6.00]	94.50 [81.39, 100.00]	**1.84×10^{-2} [1.79×10^{-2}, 1.88×10^{-2}]**	**7.33×10^{-5} [4.00×10^{-5}, 1.03×10^{-4}]**
			MEDPRAT V2.0	2.58 [0.00, 6.00]	94.69 [82.99, 100.00]	**2.86×10^{-2} [2.81×10^{-2}, 2.92×10^{-2}]**	**2.87×10^{-4} [2.27×10^{-4}, 3.50×10^{-4}]**
	27p5day	Limited	IMM	21.66 [14.00, 30.00]	96.87 [92.43, 98.80]	9.44×10^{-3} [8.85×10^{-3}, 1.00×10^{-2}]	4.70×10^{-4} [3.42×10^{-4}, 6.20×10^{-4}]
			MEDPRAT V1.0	21.51 [14.00, 29.00]	97.06 [93.26, 98.82]	**6.66×10^{-3} [6.35×10^{-3}, 6.97×10^{-3}]**	3.90×10^{-4} [3.23×10^{-4}, 4.57×10^{-4}]
			MEDPRAT V2.0	21.59 [14.00, 29.00]	97.11 [93.51, 98.81]	**1.01×10^{-2} [9.73×10^{-3}, 1.04×10^{-2}]**	6.13×10^{-4} [5.27×10^{-4}, 7.03×10^{-4}]
		Fully treated	IMM	21.66 [14.00, 30.00]	96.89 [92.60, 98.83]	2.89×10^{-3} [2.56×10^{-3}, 3.22×10^{-3}]	3.20×10^{-4} [2.23×10^{-4}, 4.40×10^{-4}]
			MEDPRAT V1.0	21.52 [14.00, 29.00]	97.44 [94.42, 98.86]	**2.22×10^{-3} [2.05×10^{-3}, 2.39×10^{-3}]**	**1.90×10^{-4} [1.40×10^{-4}, 2.37×10^{-4}]**
			MEDPRAT V2.0	21.59 [14.00, 29.00]	97.45 [94.46, 98.85]	**3.49×10^{-3} [3.28×10^{-3}, 3.70×10^{-3}]**	3.43×10^{-4} [2.80×10^{-4}, 4.07×10^{-4}]
		Untreated	IMM	21.37 [14.00, 29.00]	88.77 [69.09, 96.03]	1.58×10^{-1} [1.56×10^{-1}, 1.60×10^{-1}]	1.31×10^{-3} [1.09×10^{-3}, 1.55×10^{-3}]
			MEDPRAT V1.0	21.25 [14.00, 29.00]	88.14 [68.45, 95.56]	**1.28×10^{-1} [1.27×10^{-1}, 1.30×10^{-1}]**	**8.87×10^{-4} [7.77×10^{-4}, 9.93×10^{-4}]**
			MEDPRAT V2.0	21.58 [14.00, 29.00]	89.70 [81.25, 95.58]	**1.45×10^{-1} [1.44×10^{-1}, 1.46×10^{-1}]**	1.20×10^{-3} [1.07×10^{-3}, 1.31×10^{-3}]

3.2.5 S–435: ISS Probabilistic Risk Assessment Update (Table XIV)

TABLE XIV.—TME, CHI, EVAC/RTDC, AND LOCL FOR IMM, MEDPRAT V1.0, AND MEDPRAT V2.0 WITH THEIR RESPECTIVE 95 PERCENT CI FOR LIMITED, FULLY TREATED, AND UNTREATED PARADIGMS ACROSS ALL DRMS FOR S–435

SR	DRM	Treatment paradigm	Model	TME	CHI	EVAC/RTDC	LOCL
S-435	DRM1	Limited	IMM	98.57 [80.00, 118.00]	94.74 [84.34, 98.65]	4.30×10^{-2} [4.16×10^{-2}, 4.43×10^{-2}]	4.96×10^{-3} [4.52×10^{-3}, 5.40×10^{-3}]
			MEDPRAT V1.0	97.64 [80.00, 116.00]	95.01 [84.59, 98.76]	**4.05×10^{-2} [3.98×10^{-2}, 4.12×10^{-2}]**	**2.99×10^{-3} [2.78×10^{-3}, 3.18×10^{-3}]**
			MEDPRAT V2.0	97.98 [80.00, 117.00]	95.19 [86.10, 98.75]	4.43×10^{-2} [4.35×10^{-2}, 4.50×10^{-2}]	5.09×10^{-3} [4.84×10^{-3}, 5.34×10^{-3}]
		Fully treated	IMM	98.62 [80.00, 118.00]	94.90 [84.69, 98.70]	3.24×10^{-2} [3.12×10^{-2}, 3.35×10^{-2}]	4.90×10^{-3} [4.46×10^{-3}, 5.34×10^{-3}]
			MEDPRAT V1.0	97.67 [80.00, 116.00]	95.20 [85.12, 98.80]	**2.93×10^{-2} [2.87×10^{-2}, 2.99×10^{-2}]**	**3.08×10^{-3} [2.88×10^{-3}, 3.28×10^{-3}]**
			MEDPRAT V2.0	97.96 [80.00, 117.00]	95.35 [86.42, 98.79]	**3.86×10^{-2} [3.79×10^{-2}, 3.93×10^{-2}]**	5.22×10^{-3} [4.97×10^{-3}, 5.49×10^{-3}]
		Untreated	IMM	94.14 [72.00, 115.00]	63.67 [49.08, 74.60]	5.05×10^{-1} [5.02×10^{-1}, 5.08×10^{-1}]	1.98×10^{-2} [1.90×10^{-2}, 2.07×10^{-2}]
			MEDPRAT V1.0	93.13 [72.00, 114.00]	63.31 [48.50, 74.45]	**4.95×10^{-1} [4.93×10^{-1}, 4.97×10^{-1}]**	**1.28×10^{-2} [1.24×10^{-2}, 1.32×10^{-2}]**
			MEDPRAT V2.0	97.84 [80.00, 117.00]	65.67 [55.39, 74.86]	**5.24×10^{-1} [5.22×10^{-1}, 5.26×10^{-1}]**	**2.21×10^{-2} [2.15×10^{-2}, 2.26×10^{-2}]**

3.2.6 S–441: HSRB Point of Departure—Basis of Comparison (Table XV)

TABLE XV.—TME, CHI, EVAC/RTDC, AND LOCL FOR IMM, MEDPRAT V1.0, AND MEDPRAT V2.0 WITH THEIR RESPECTIVE 95 PERCENT CI FOR LIMITED, FULLY TREATED, AND UNTREATED PARADIGMS ACROSS ALL DRMS FOR S–441

SR	DRM	Treatment paradigm	Model	TME	CHI	EVAC/RTDC	LOCL
S-441	PoD	Limited	IMM	255.55 [206.00, 292.00]	81.19 [63.97, 91.19]	2.16×10^{-1} [2.14×10^{-1}, 2.19×10^{-1}]	1.17×10^{-2} [1.10×10^{-2}, 1.23×10^{-2}]
			MEDPRAT V1.0	252.53 [204.00, 288.00]	81.32 [63.94, 91.30]	**2.21×10^{-1} [2.20×10^{-1}, 2.23×10^{-1}]**	**7.05×10^{-3} [6.75×10^{-3}, 7.35×10^{-3}]**
			MEDPRAT V2.0	258.20 [227.00, 290.00]	82.60 [68.18, 91.36]	**2.07×10^{-1} [2.06×10^{-1}, 2.09×10^{-1}]**	1.15×10^{-2} [1.11×10^{-2}, 1.19×10^{-2}]
		Fully treated	IMM	258.00 [212.00, 293.00]	88.42 [71.10, 96.47]	8.79×10^{-2} [8.62×10^{-2}, 8.96×10^{-2}]	1.12×10^{-2} [1.05×10^{-2}, 1.19×10^{-2}]
			MEDPRAT V1.0	255.55 [212.00, 289.00]	88.70 [71.20, 96.62]	**8.28×10^{-2} [8.17×10^{-2}, 8.37×10^{-2}]**	**6.47×10^{-3} [6.18×10^{-3}, 6.76×10^{-3}]**
			MEDPRAT V2.0	258.15 [227.00, 290.00]	89.39 [74.51, 96.66]	8.77×10^{-2} [8.67×10^{-2}, 8.87×10^{-2}]	1.09×10^{-2} [1.05×10^{-2}, 1.12×10^{-2}]
		Untreated	IMM	200.59 [109.00, 274.00]	23.86 [14.39, 35.00]	8.92×10^{-1} [8.90×10^{-1}, 8.94×10^{-1}]	4.50×10^{-2} [4.38×10^{-2}, 4.63×10^{-2}]
			MEDPRAT V1.0	197.06 [108.00, 270.00]	23.20 [14.01, 31.51]	**9.02×10^{-1} [9.01×10^{-1}, 9.03×10^{-1}]**	**2.83×10^{-2} [2.77×10^{-2}, 2.89×10^{-2}]**
			MEDPRAT V2.0	256.69 [219.00, 289.00]	25.78 [19.21, 32.58]	**9.08×10^{-1} [9.07×10^{-1}, 9.09×10^{-1}]**	**5.79×10^{-2} [5.70×10^{-2}, 5.87×10^{-2}]**
	AS	Limited	IMM	300.28 [239.00, 342.00]	76.46 [59.35, 87.40]	2.86×10^{-1} [2.84×10^{-1}, 2.89×10^{-1}]	1.36×10^{-2} [1.28×10^{-2}, 1.43×10^{-2}]
			MEDPRAT V1.0	302.67 [241.00, 343.00]	76.41 [59.17, 87.31]	**2.93×10^{-1} [2.91×10^{-1}, 2.94×10^{-1}]**	**8.47×10^{-3} [8.14×10^{-3}, 8.81×10^{-3}]**
			MEDPRAT V2.0	305.33 [271.00, 340.00]	78.15 [63.78, 87.63]	**2.75×10^{-1} [2.74×10^{-1}, 2.77×10^{-1}]**	1.41×10^{-2} [1.37×10^{-2}, 1.45×10^{-2}]
		Fully treated	IMM	304.60 [247.00, 344.00]	86.95 [69.06, 95.67]	1.03×10^{-1} [1.01×10^{-1}, 1.05×10^{-1}]	1.29×10^{-2} [1.22×10^{-2}, 1.36×10^{-2}]
			MEDPRAT V1.0	308.03 [252.00, 346.00]	86.96 [69.14, 95.63]	**9.89×10^{-2} [9.79×10^{-2}, 1.00×10^{-1}]**	**8.19×10^{-3} [7.86×10^{-3}, 8.50×10^{-3}]**
			MEDPRAT V2.0	305.36 [271.00, 340.00]	87.97 [72.92, 95.82]	1.04×10^{-1} [1.03×10^{-1}, 1.06×10^{-1}]	1.33×10^{-2} [1.29×10^{-2}, 1.38×10^{-2}]
		Untreated	IMM	225.95 [117.00, 319.00]	20.19 [12.04, 32.60]	9.28×10^{-1} [9.27×10^{-1}, 9.30×10^{-1}]	5.02×10^{-2} [4.89×10^{-2}, 5.15×10^{-2}]
			MEDPRAT V1.0	225.40 [115.00, 319.00]	19.26 [11.65, 26.23]	**9.39×10^{-1} [9.39×10^{-1}, 9.40×10^{-1}]**	**3.25×10^{-2} [3.18×10^{-2}, 3.31×10^{-2}]**
			MEDPRAT V2.0	303.25 [257.00, 339.00]	21.75 [16.14, 27.58]	**9.42×10^{-1} [9.41×10^{-1}, 9.42×10^{-1}]**	**6.83×10^{-2} [6.74×10^{-2}, 6.92×10^{-2}]**
	BoC	Limited	IMM	413.44 [319.00, 474.00]	68.21 [51.90, 80.66]	4.94×10^{-1} [4.91×10^{-1}, 4.97×10^{-1}]	1.70×10^{-2} [1.62×10^{-2}, 1.79×10^{-2}]
			MEDPRAT V1.0	413.53 [322.00, 468.00]	69.80 [53.32, 81.46]	**4.16×10^{-1} [4.14×10^{-1}, 4.17×10^{-1}]**	**1.02×10^{-2} [9.81×10^{-3}, 1.05×10^{-2}]**
			MEDPRAT V2.0	432.16 [390.00, 473.00]	71.58 [57.74, 81.74]	**3.98×10^{-1} [3.96×10^{-1}, 4.00×10^{-1}]**	1.72×10^{-2} [1.68×10^{-2}, 1.77×10^{-2}]
		Fully treated	IMM	430.24 [342.00, 480.00]	83.90 [65.97, 93.40]	1.23×10^{-1} [1.21×10^{-1}, 1.25×10^{-1}]	1.59×10^{-2} [1.51×10^{-2}, 1.67×10^{-2}]
			MEDPRAT V1.0	425.87 [341.00, 472.00]	84.26 [66.30, 93.58]	**1.16×10^{-1} [1.15×10^{-1}, 1.17×10^{-1}]**	**9.38×10^{-3} [9.03×10^{-3}, 9.72×10^{-3}]**
			MEDPRAT V2.0	432.25 [390.00, 473.00]	85.19 [70.13, 93.65]	1.24×10^{-1} [1.23×10^{-1}, 1.26×10^{-1}]	1.56×10^{-2} [1.51×10^{-2}, 1.60×10^{-2}]
		Untreated	IMM	271.15 [123.00, 415.00]	17.04 [10.07, 31.20]	9.86×10^{-1} [9.85×10^{-1}, 9.87×10^{-1}]	5.81×10^{-2} [5.66×10^{-2}, 5.95×10^{-2}]
			MEDPRAT V1.0	277.42 [127.00, 420.00]	16.31 [9.86, 22.15]	**9.81×10^{-1} [9.80×10^{-1}, 9.81×10^{-1}]**	**3.37×10^{-2} [3.31×10^{-2}, 3.44×10^{-2}]**
			MEDPRAT V2.0	**428.21 [353.00, 472.00]**	18.19 [13.51, 23.00]	**9.83×10^{-1} [9.83×10^{-1}, 9.84×10^{-1}]**	**8.80×10^{-2} [8.70×10^{-2}, 8.90×10^{-2}]**

3.2.7 S–442: Risk Posture for EMAC 4.0 Artemis IV (Table XVI)

TABLE XVI.—TME, CHI, EVAC/RTDC, AND LOCL FOR IMM, MEDPRAT V1.0, AND MEDPRAT V2.0 WITH THEIR RESPECTIVE 95 PERCENT CI FOR LIMITED, FULLY TREATED, AND UNTREATED PARADIGMS ACROSS ALL DRMS FOR S–442

SR	DRM	Treatment paradigm	Model	TME	CHI	EVAC/RTDC	LOCL
S-442	15 day_opt	Limited	IMM	15.60 [10.00, 22.00]	96.67 [92.34, 98.72]	6.74×10^{-3} [6.44×10^{-3}, 7.04×10^{-3}]	6.40×10^{-4} [5.50×10^{-4}, 7.30×10^{-4}]
			MEDPRAT V1.0	15.56 [10.00, 22.00]	96.93 [93.26, 98.74]	**3.84×10^{-3} [3.62×10^{-3}, 4.06×10^{-3}]**	**4.17×10^{-4} [3.43×10^{-4}, 4.87×10^{-4}]**
			MEDPRAT V2.0	15.61 [10.00, 22.00]	96.94 [93.37, 98.73]	6.66×10^{-3} [6.38×10^{-3}, 6.95×10^{-3}]	**5.30×10^{-4} [4.57×10^{-4}, 6.10×10^{-4}]**
		Fully treated	IMM	15.60 [10.00, 22.00]	96.55 [91.80, 98.75]	1.62×10^{-3} [1.49×10^{-3}, 1.78×10^{-3}]	1.87×10^{-4} [1.43×10^{-4}, 2.40×10^{-4}]
			MEDPRAT V1.0	15.57 [10.00, 22.00]	97.24 [94.28, 98.76]	**1.27×10^{-3} [1.13×10^{-3}, 1.40×10^{-3}]**	**1.20×10^{-4} [8.00×10^{-5}, 1.57×10^{-4}]**
			MEDPRAT V2.0	15.61 [10.00, 22.00]	97.25 [94.27, 98.75]	**1.98×10^{-3} [1.81×10^{-3}, 2.14×10^{-3}]**	1.63×10^{-4} [1.17×10^{-4}, 2.07×10^{-4}]
		Untreated	IMM	15.46 [10.00, 22.00]	91.82 [71.85, 97.21]	1.02×10^{-1} [1.01×10^{-1}, 1.03×10^{-1}]	9.70×10^{-4} [8.70×10^{-4}, 1.08×10^{-3}]
			MEDPRAT V1.0	15.42 [10.00, 22.00]	90.58 [70.64, 96.71]	**8.92×10^{-2} [8.82×10^{-2}, 9.02×10^{-2}]**	**5.93×10^{-4} [5.07×10^{-4}, 6.83×10^{-4}]**
			MEDPRAT V2.0	15.61 [10.00, 22.00]	92.11 [84.87, 96.71]	**1.06×10^{-1} [1.05×10^{-1}, 1.07×10^{-1}]**	1.03×10^{-3} [9.17×10^{-4}, 1.14×10^{-3}]
	17 day_opt	Limited	IMM	16.18 [10.00, 23.00]	96.87 [92.61, 98.82]	7.69×10^{-3} [7.39×10^{-3}, 8.02×10^{-3}]	6.13×10^{-4} [5.33×10^{-4}, 7.07×10^{-4}]
			MEDPRAT V1.0	16.11 [10.00, 23.00]	97.12 [93.48, 98.83]	**4.31×10^{-3} [4.06×10^{-3}, 4.54×10^{-3}]**	**5.10×10^{-4} [4.27×10^{-4}, 5.93×10^{-4}]**
			MEDPRAT V2.0	16.15 [10.00, 23.00]	97.15 [93.63, 98.83]	**6.97×10^{-3} [6.68×10^{-3}, 7.29×10^{-3}]**	6.70×10^{-4} [5.70×10^{-4}, 7.67×10^{-4}]
		Fully treated	IMM	16.18 [10.00, 23.00]	96.78 [92.20, 98.84]	1.93×10^{-3} [1.79×10^{-3}, 2.10×10^{-3}]	1.43×10^{-4} [1.01×10^{-4}, 1.90×10^{-4}]
			MEDPRAT V1.0	16.13 [10.00, 23.00]	97.42 [94.47, 98.85]	**1.42×10^{-3} [1.29×10^{-3}, 1.57×10^{-3}]**	1.27×10^{-4} [8.33×10^{-5}, 1.67×10^{-4}]
			MEDPRAT V2.0	16.15 [10.00, 23.00]	97.43 [94.51, 98.85]	**2.19×10^{-3} [2.01×10^{-3}, 2.35×10^{-3}]**	**1.93×10^{-4} [1.43×10^{-4}, 2.40×10^{-4}]**
		Untreated	IMM	16.02 [10.00, 23.00]	91.71 [71.49, 97.27]	1.06×10^{-1} [1.05×10^{-1}, 1.07×10^{-1}]	1.06×10^{-3} [9.50×10^{-4}, 1.18×10^{-3}]
			MEDPRAT V1.0	15.95 [10.00, 22.00]	90.57 [70.45, 96.78]	**9.41×10^{-2} [9.31×10^{-2}, 9.51×10^{-2}]**	**7.17×10^{-4} [6.23×10^{-4}, 8.00×10^{-4}]**
			MEDPRAT V2.0	16.15 [10.00, 23.00]	92.17 [84.86, 96.81]	**1.11×10^{-1} [1.10×10^{-1}, 1.12×10^{-1}]**	1.08×10^{-3} [9.73×10^{-4}, 1.19×10^{-3}]
	23 day_opt	Limited	IMM	17.86 [11.00, 25.00]	97.25 [92.93, 98.98]	1.03×10^{-2} [9.95×10^{-3}, 1.07×10^{-2}]	8.53×10^{-4} [7.37×10^{-4}, 9.50×10^{-4}]
			MEDPRAT V1.0	17.78 [11.00, 25.00]	97.46 [93.73, 99.00]	**6.61×10^{-3} [6.29×10^{-3}, 6.90×10^{-3}]**	**5.73×10^{-4} [4.90×10^{-4}, 6.60×10^{-4}]**
			MEDPRAT V2.0	17.83 [11.00, 25.00]	97.51 [93.95, 99.00]	**9.59×10^{-3} [9.27×10^{-3}, 9.96×10^{-3}]**	8.70×10^{-4} [7.57×10^{-4}, 9.70×10^{-4}]
		Fully treated	IMM	17.87 [11.00, 25.00]	97.21 [92.83, 99.01]	2.61×10^{-3} [2.44×10^{-3}, 2.84×10^{-3}]	2.90×10^{-4} [2.36×10^{-4}, 3.56×10^{-4}]
			MEDPRAT V1.0	17.80 [11.00, 25.00]	97.75 [94.78, 99.02]	**1.93×10^{-3} [1.76×10^{-3}, 2.07×10^{-3}]**	**1.87×10^{-4} [1.37×10^{-4}, 2.37×10^{-4}]**
			MEDPRAT V2.0	17.82 [11.00, 25.00]	97.76 [94.81, 99.01]	**3.08×10^{-3} [2.89×10^{-3}, 3.26×10^{-3}]**	3.37×10^{-4} [2.67×10^{-4}, 3.97×10^{-4}]
		Untreated	IMM	17.67 [11.00, 25.00]	91.09 [70.44, 97.22]	1.19×10^{-1} [1.18×10^{-1}, 1.20×10^{-1}]	1.51×10^{-3} [1.38×10^{-3}, 1.66×10^{-3}]
			MEDPRAT V1.0	17.59 [11.00, 25.00]	90.14 [69.57, 96.77]	**1.06×10^{-1} [1.05×10^{-1}, 1.07×10^{-1}]**	**1.03×10^{-3} [9.13×10^{-4}, 1.14×10^{-3}]**
			MEDPRAT V2.0	17.84 [11.00, 25.00]	91.85 [84.03, 96.80]	**1.26×10^{-1} [1.24×10^{-1}, 1.27×10^{-1}]**	1.61×10^{-3} [1.47×10^{-3}, 1.76×10^{-3}]

3.3 Comparing Resource Quantity Means

To compare medical resource results, consumable medications have been placed into categories that were developed for IMM's Real World System Validation. Resource consumption is compared for a limited treatment paradigm. A logarithmic scale is used on the graphs in Figure 29 to Figure 35 to show resource categories with relatively small values alongside some of the resource categories with larger values.

Across all scenarios, all models report the category non-opioid analgesic/nonsteroidal anti-inflammatory drug (NSAID) as having the highest consumption of its respective resources. When comparing the totals for each resource category, the resource quantity mean estimates vary between IMM and MEDPRAT V1.0 and V2.0 due to the difference for treatment implementation of per day dosing in assumption 1.1 and end of mission dosing in assumption 1.4. IMM decrements resources once the condition occurs and caps end of mission dosage prescribed. MEDPRAT V1.0 and V2.0 decrement the resources each day and have no cap for resources prescribed to end of mission, but are instead consumed until the scheduled mission end. This effect is more notable in long-duration missions where IMM will report slightly higher consumption in a few categories (e.g., S–386 DRM 1, 2, 3; S–387 DRM 3, 6, 9; and S–441 DRM BoC). In many cases, particularly for longer duration missions, MEDPRAT V2.0 resource consumption is more pronounced due to assumption 2. MEDPRAT V2.0 keeps crew in the simulation after being scheduled for RTDC; therefore, crew can consume more resources given that they are kept in the simulation for longer.

3.3.1 S–386: Risk of Appendicitis and Cholecystitis Versus Risk of SBO Following Prophylactic Surgery

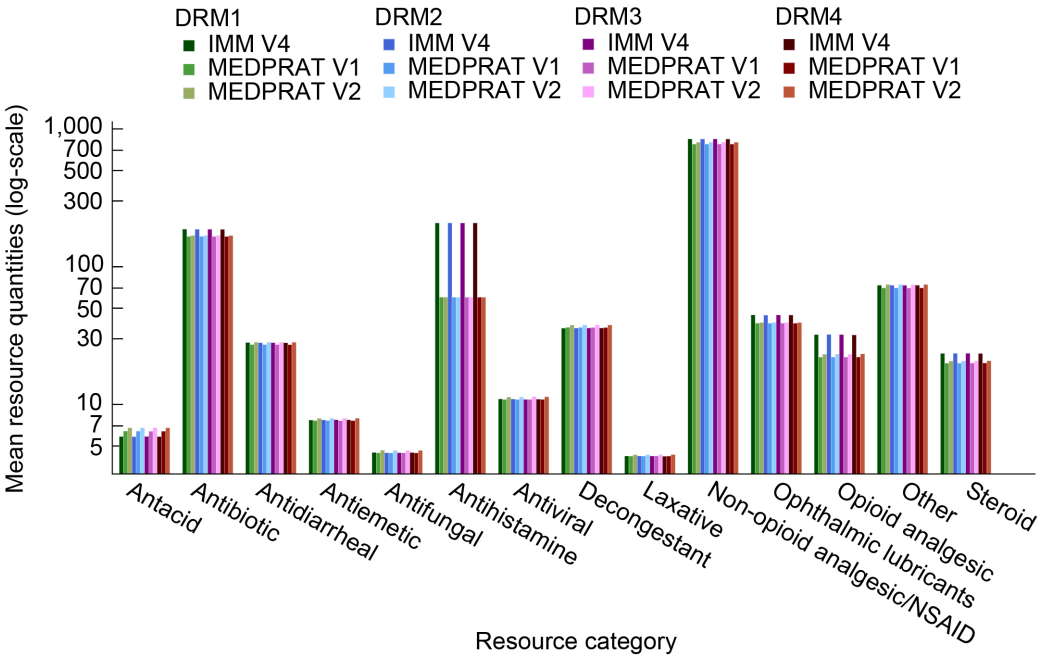

Figure 29.—Resource quantity means (on log scale) by category for IMM, MEDPRAT V1.0, and MEDPRAT V2.0.

3.3.2 S–387: Impact of Sex on Medical Outcomes for Deep Space Missions

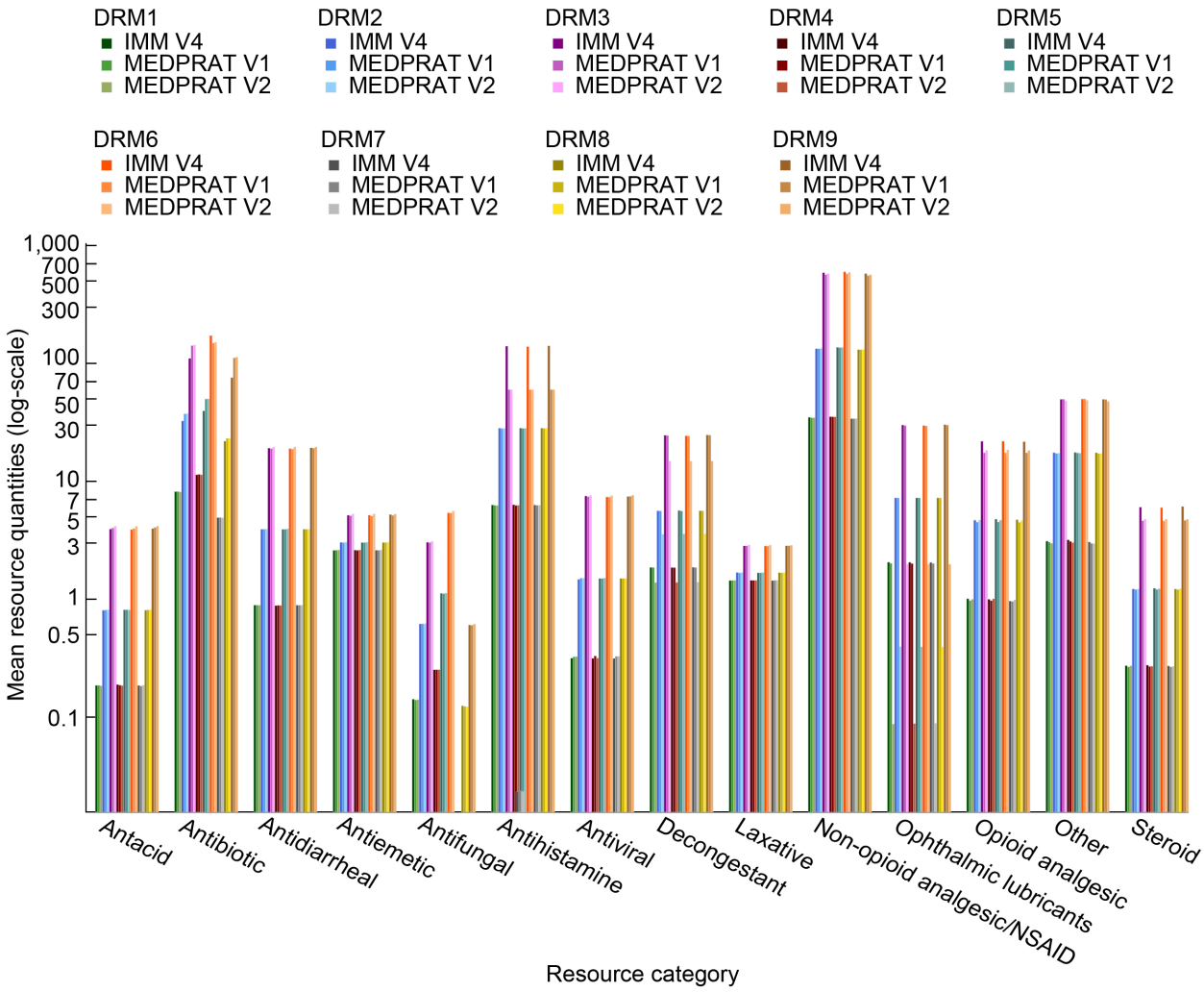

Figure 30.—Resource quantity means (on log scale) by category for IMM, MEDPRAT V1.0, and MEDPRAT V2.0.

3.3.3 S–388: Impact of Heroic Medical Care Measures on Subsequent Medical Outcomes

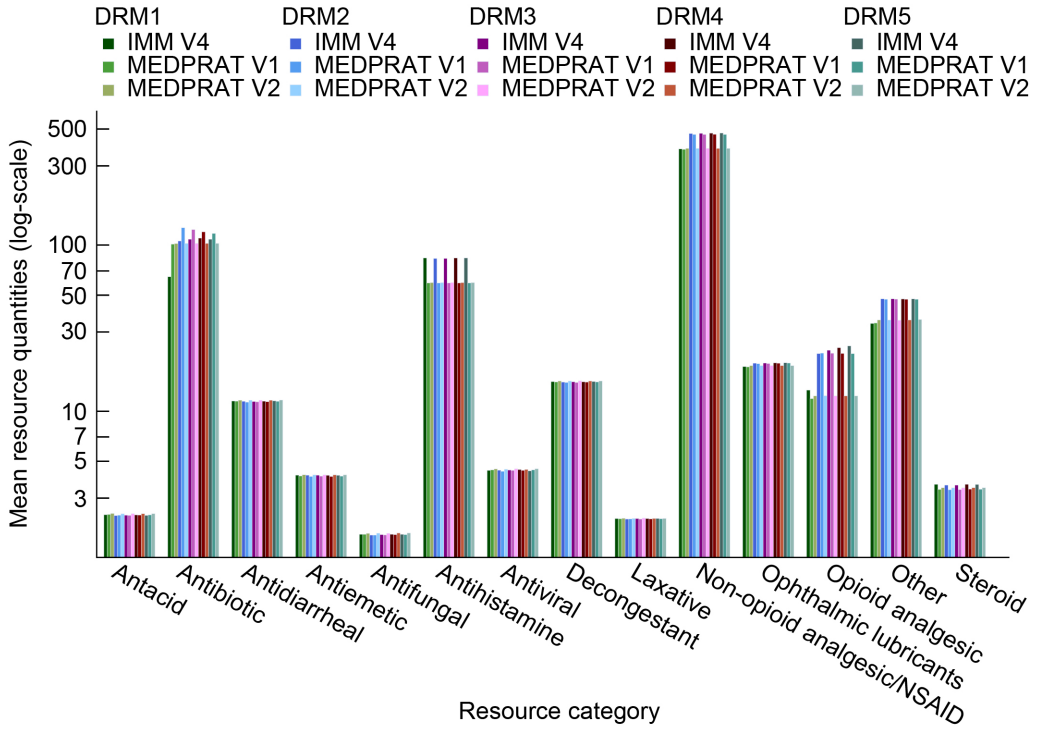

Figure 31.—Resource quantity means (on log scale) by category for IMM, MEDPRAT V1.0, and MEDPRAT V2.0.

3.3.4 S–412: Lunar 27.5-Day and 7.5-Day Assessment

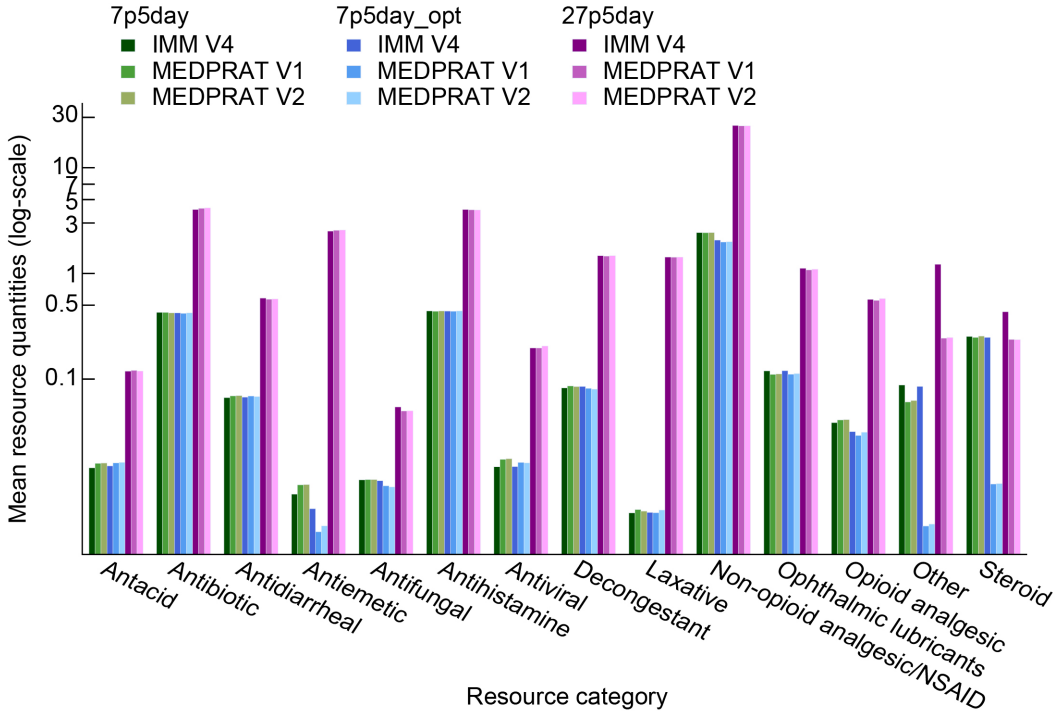

Figure 32.—Resource quantity means (on log scale) by category for IMM, MEDPRAT V1.0, and MEDPRAT V2.0.

3.3.5 S–435: ISS Probabilistic Risk Assessment Update

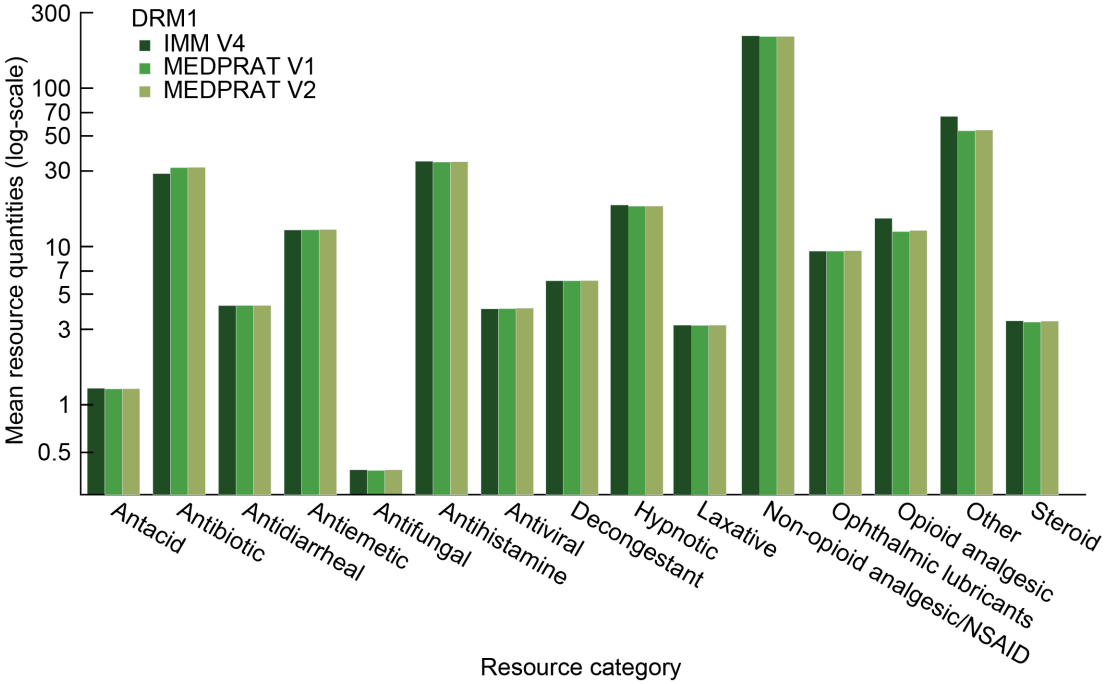

Figure 33.—Resource quantity means (on log scale) by category for IMM, MEDPRAT V1.0, and MEDPRAT V2.0.

3.3.6 S–441: HSRB Point of Departure—Basis of Comparison

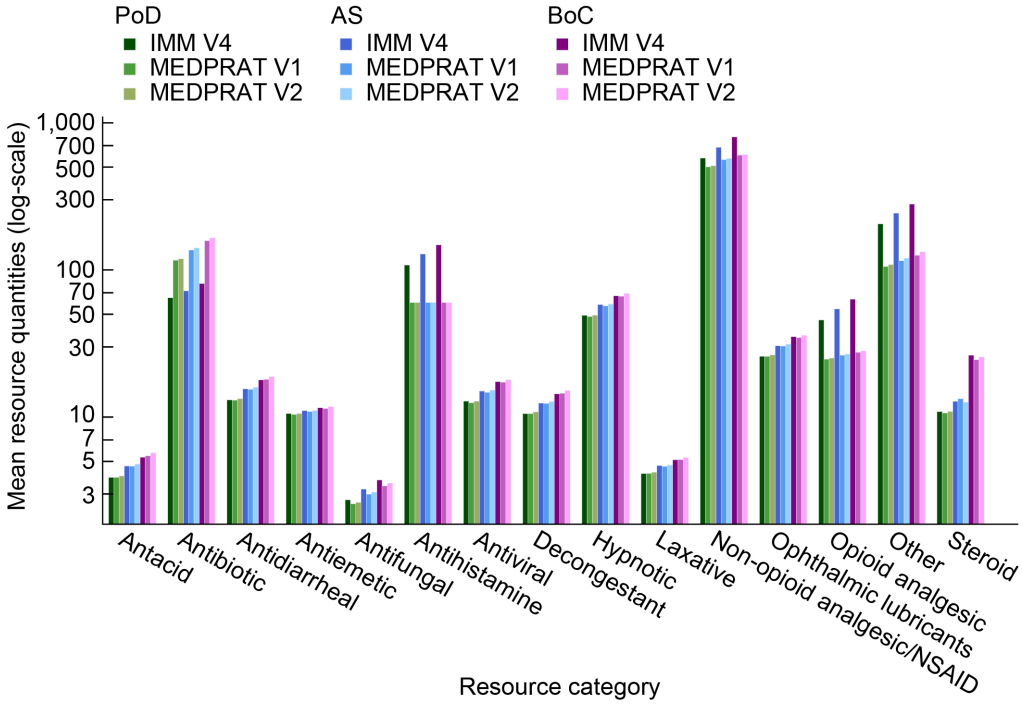

Figure 34.—Resource quantity means (on log scale) by category for IMM, MEDPRAT V1.0, and MEDPRAT V2.0.

3.3.7 S–442: Risk Posture for EMAC 4.0 Artemis IV

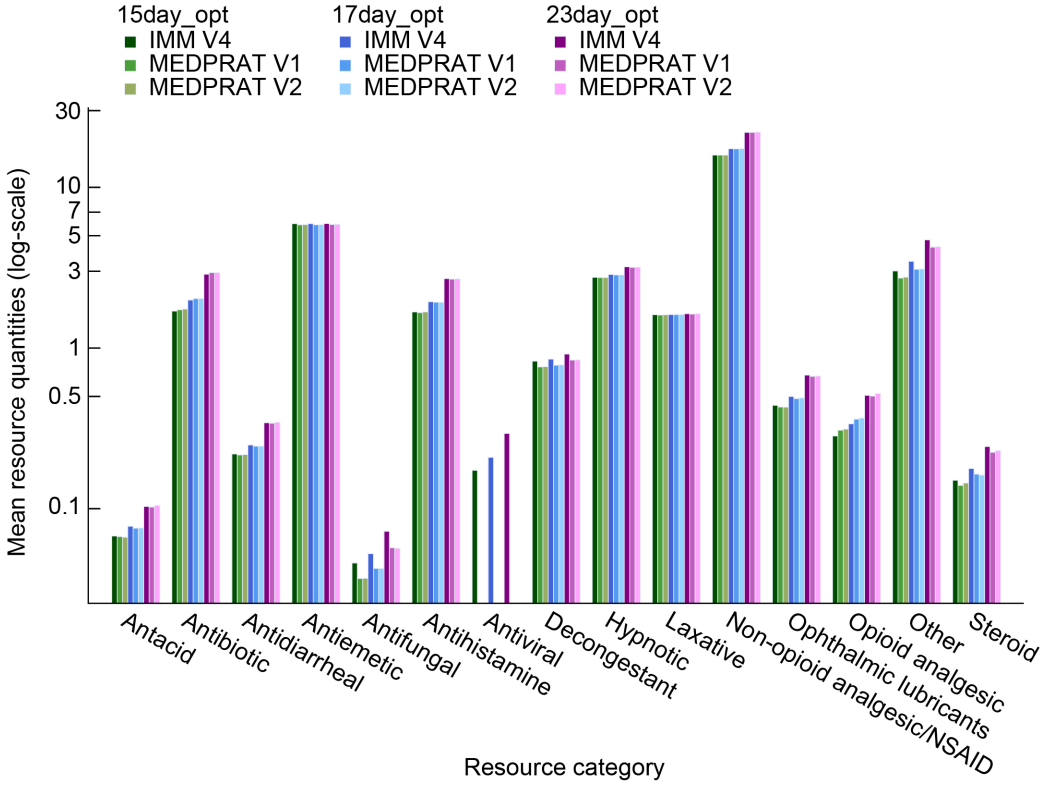

Figure 35.—Resource quantity means (on log scale) by category for IMM, MEDPRAT V1.0, and MEDPRAT V2.0.

3.4 Optimized Medical Set Comparison

A comparison for the optimized medical sets is performed between IMM and MEDPRAT V1.0. This comparison with IMM is only performed against MEDPRAT V1.0 (not MEDPRAT V2.0) because the set selector algorithm, minus the segments addition, in MEDPRAT V2.0, is the same as in MEDPRAT V1.0. To compare optimized medical sets, 300,000 MEDPRAT V1.0 simulations are run. One optimized medical set has a mass constraint of 9.07 kg with no limitations on its volume. The other medical set has the same mass constraint of 9.07 kg and a 13,721-cm^3 volume limitation. CHI was prioritized during optimization of both medical sets. The post-optimization resulting mass and volume for each set are summarized in Table XVII. It is important to note that fractional resources quantities were rounded up to accurately represent each medical resource. Mass and volume of each set is calculated after each resource is rounded. Therefore, it is possible for a set to report higher than the constraint restriction.

3.4.1 S–406: Orion Medical Set Contents

Both MEDPRAT V1.0 optimized medical sets have less mass and volume than the IMM medical set. In both MEDPRAT V1.0 and IMM models, crew members are removed from the simulation after RTDC, as assumption 2 states. Therefore, RTDC results from each optimized medical set can be compared directly. Assumption 1.2 should be considered when comparing LOCL, as it is expected to see IMM reporting slightly higher LOCL when compared to MEDPRAT V1.0. The MEDPRAT V1.0 optimized medical sets produce lower risk outcomes than the IMM optimized medical sets for both the mass-constrained and volume- and mass-constrained sets. It should be noted that although MEDPRAT does

produce medical sets that result in better risk outcomes, all the risk metric outcomes between IMM and MEDPRAT belong to the same order of magnitude and the differences are at the third or fourth decimal point, as seen in Table XVII. The contents of both medical sets are given in Table XVIII.

TABLE XVII.—COMPARING IMM AND MEDPRAT V1.0 MASS, VOLUME, CHI, LOCL, AND RTDC FOR BOTH OPTIMIZED MEDICAL SETS

	IMM		MEDPRAT	
	9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set	9.07-kg mass-constrained medical set	9.07-kg mass- and 13.721-cm^3 volume-constrained medical set
Mass, kg	9.25	7.76	8.51	5.86
Volume, cm^3	23,594.34	13,895.43	18,825.14	12,999.73
CHI	97.2	97.2	97.6	97.6
LOCL	0.0005	0.0005	0.0003	0.0003
RTDC	0.0065	0.0074	0.0022	0.0036

TABLE XVIII.—COMPARING IMM AND MEDPRAT V1.0 RESOURCE COUNTS FOR BOTH OPTIMIZED MEDICAL SETS

IMM quantity		Resource	MEDPRAT quantity	
9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set		9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set
0	0	Abilify®[1] (aripiprazole), 5 mg	0	0
0	0	Abilify® (aripiprazole), 7.5 mg/mL, 1.3 mL	0	0
2	2	Absorbable suture 3.0	1	1
1	1	Ace®[2] bandage, 2 in.	1	1
1	1	Ace® bandage, 3 in.	1	1
1	1	Ace® bandage, 4 in.	1	1
0	0	Adrenaline (epinephrine 1:10,000), 10 mL	0	0
0	0	AED	0	0
1	1	Afrin®[3] (oxymetazoline), 0.05% 15-mL bottle	2	2
1	2	Albuterol inhaler (Proventil®[4]), 90 mcg, 6.7 g	1	1
11	11	Ambien®[5], 10-mg tablet	10	10
0	0	AMBU bag and mask	0	0
22	22	Amoxicillin, 500-mg capsule	34	34

[1]Otsuka Pharmaceutical Co.
[2]3M Company
[3]Bayer Healthcare LLC
[4]Merck Sharp & Dohme LLC
[5]Cosette Pharmaceuticals, Inc.

TABLE XVIII.—COMPARING IMM AND MEDPRAT V1.0 RESOURCE COUNTS FOR BOTH OPTIMIZED MEDICAL SETS

IMM quantity		Resource	MEDPRAT quantity	
9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set		9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set
0	0	Antivert®[6] (meclizine), 25 mg	0	0
1	1	Aspirin, 325-mg tablet	1	1
31	42	Ativan®[7] (lorazepam), 1-mg tablet	6	6
0	0	Atropine, 1-mg, 10-mL syringe	0	0
1	1	Bacitracin, 500 units/g 28-g tube	2	2
40	40	Bactrim DS (sulfamethoxazole/trimethoprim), 800-mg/160-mg tablet	40	40
0	0	Band-Aid®[8] (2×3)	0	0
0	0	Band-Aid® (knuckle)	0	0
0	0	Band-Aid® dot	0	0
0	0	Band-Aid® strip	0	0
26	26	Benadryl®[9] 25-mg capsule	24	24
1	1	Benadryl®, 50 mg/mL, 1-mL injectable	1	1
0	0	Benzocaine swab stick oral, 20%, 0.15-ml swab	0	0
0	0	Biohazard trash bag	0	0
1	1	Blood oximeter	1	1
0	0	Blood pressure/ECG monitor	0	0
0	0	Blood pressure cuff—large	1	1
0	0	Blood pressure cuff—small	0	0
0	0	Bougie ET tube introducer	0	0
0	0	Burn bandage	0	0
0	0	BZK wipes	0	0
0	0	Camera	0	0
1	1	Ciprofloxacin and dexamethasone (Ciprodex®[10]) 3%, 7%, 7.5-mL bottle	1	1
0	0	Claritin®[11] (loratadine)10-mg tablet	0	0
0	0	Clear bandage	0	0
21	21	Cleocin®[12] (clindamycin) 300 mg	21	21
0	0	CMRS	0	0

[6]Casper Pharma, LLC
[7]Bausch Health Ireland Limited
[8]Kenvue Inc.
[9]Kenvue Inc.
[10]Bayer Aktiengesellschaft
[11]Bayer Healthcare LLC
[12]Pharmacia & Upjohn Company LLC

TABLE XVIII.—COMPARING IMM AND MEDPRAT V1.0 RESOURCE COUNTS FOR BOTH OPTIMIZED MEDICAL SETS

IMM quantity		Resource	MEDPRAT quantity	
9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set		9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set
0	0	Cotton balls	0	0
0	0	Cotton pellet	0	0
0	0	Cotton swabs	0	0
1	1	Cyclopentolate, 2% 15-mL bottle	1	1
0	0	DCS examination scorecard	0	0
0	0	Debrox for earwax (carbamide peroxide), 6.5%, 15-mL bottle	0	0
1	1	Dental adhesive (76 g)	1	0
1	1	Dental adhesive tip	1	0
0	0	Dental amalgam file	0	0
1	1	Dental carver file (G)	0	1
0	0	Dental crown remover	0	0
1	1	Dental elevator—301 (I)	1	1
1	1	Dental elevator—34S (J)	1	1
2	2	Dental eugenol anesthetic, 1-mL oral syringe	2	2
1	1	Dental explorer/probe (E)	1	1
0	1	Dental forceps—10S (A)	0	0
0	1	Dental forceps—151A (B)	0	0
0	1	Dental forceps—17 (C)	0	0
1	1	Dental mirror (H)	1	1
0	0	Dental syringe (tubex)	0	0
1	1	Dermabond®[13] applicator, 0.5-ml	1	1
1	1	Dexamethasone (Decadron®[14]), 10-mg injectable	1	1
6	6	Diamox (acetazolamide), 250-mg tablets	6	0
1	1	Diflucan®[15] (fluconazole), 150 mg	4	4
6	6	Dilantin®[16] (phenytoin), 300-mg capsules	0	0
6	6	Dilaudid®[17] (hydromorphone), 2 mg/mL, 1-mL syringe	3	3
0	0	Disposable otoscope specula	0	0
14	16	Dulcolax®[18] (bisacodyl) tablet, 5 mg	16	14

[13]Johnson & Johnson
[14]Pragma Pharmaceuticals
[15]Pfizer Inc.
[16]Viatris Specialy LLC
[17]Purdue Pharma L.P.
[18]A. Nattermann & Cie GmbH

TABLE XVIII.—COMPARING IMM AND MEDPRAT V1.0 RESOURCE COUNTS FOR BOTH OPTIMIZED MEDICAL SETS

IMM quantity		Resource	MEDPRAT quantity	
9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set		9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set
0	0	Ear curette	0	0
2	2	Ear wick	2	1
0	0	Effexor XR®[19] (venlafaxine XR), 75-mg capsules	21	21
0	1	Endotracheal stylet	0	0
1	1	EpiPen®[20] 1:1000	1	1
1	1	E.P.T.®[21]	1	0
6	6	Ertapenem, 1 g	6	6
1	1	Erythromycin ointment, 0.5%, 3.5-g tube	1	1
7	7	Estrogen, 1.25-mg tablets	7	7
0	0	Ethinyl estradiol/norgestrel, 0.05 mg/0.5 mg	0	0
0	0	Eye shield	0	0
0	0	Eye simulator cornea	0	0
1	1	Eye wash goggles and tubing	1	1
3	3	Eye wash wastewater bag	2	2
1	1	Finger splint	1	1
30	30	Flagyl®[22] (metronidazole), 500 mg	30	30
1	1	Fluocinonide, 0.05%, 30-g tube	1	1
6	6	Fluorescein, 1-mg strips	6	5
0	0	Fluticasone, 220-mcg, 12-g inhaler	0	0
10	10	Foam electrodes	5	5
0	0	G1 camcorder	0	0
0	0	Gauze pads (4×4)	0	0
1	1	Heimlich maneuver	1	1
0	1	Hemostats	0	0
0	0	Hot and cold pad	0	0
1	1	ILMA cue card	1	0
1	1	ILMA endotracheal tube 7.0/7.5 and endotracheal tube 7.0/8.0	0	0
0	0	ILMA hardware	0	0
1	1	ILMA stabilizing rod	0	0
0	0	ILMA syringe	0	0

[19]Viatris Specialty LLC
[20]Mylan Inc.
[21]NFI, LLC
[22]Wyeth Holdings

TABLE XVIII.—COMPARING IMM AND MEDPRAT V1.0 RESOURCE COUNTS FOR BOTH OPTIMIZED MEDICAL SETS

IMM quantity		Resource	MEDPRAT quantity	
9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set		9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set
24	24	Imodium®[23] (loperamide HCL) 2-mg tablet	25	20
1	1	Intraosseous device starter kit	1	1
1	1	Intraosseous injection device	1	1
0	0	Iodine swab stick	0	0
2	2	IV administration set	1	1
2	2	IV cap	2	2
0	0	IV catheter (14 G)	0	0
2	2	IV catheter (18 G)	2	2
2	2	IV catheter (20 G)	2	1
1	1	IV catheter (22 G)	1	0
2	0	IV fluid 1 L (1,000 mL)	2	0
1	1	IV pressure infuser	1	1
1	1	Ketamine, 50 mg/mL, 10-mL multidose vial	1	0
0	0	Laryngoscope (blade)	0	0
0	0	Laryngoscope handle	0	0
0	0	Levaquin®[24] (levofloxacin) 500 mg	15	14
0	0	Lidocaine (Xylocaine[25]) cardiac, 2% (20 mg/mL) 5-mL syringe	0	0
1	1	Lidocaine (Xylocaine®) plain 1%, 10-mL multidose vial	1	1
2	2	Lidocaine jelly, 2% 30-mL tube	1	1
1	1	Lidocaine with epinephrine (Xylocaine®), 2 %, 2-mL units 1:100,000 EPI, 20 mL multidose vials	1	1
60	62	Lopressor®[26] (metoprolol), 50 mg	38	40
2	2	Lotrimin AF®[27] cream (clotrimazole), 1%, 30-g tube	2	2
0	0	Maximum absorbency garment (MAG)	0	0
0	0	Medical tape	0	0
0	0	Melatonin, 3 mg	0	0
0	0	Mirror	0	0
52	55	Motrin®[28] (ibuprofen), 400 mg	80	78

[23]Kenvue Inc.
[24]Daiichi Sankyo Company, Limited
[25]Fresenius Kabi USA, LLC
[26]Novartis Pharmaceuticals Corporation
[27]Bayer Healthcare LLC
[28]Kenvue Inc.

TABLE XVIII.—COMPARING IMM AND MEDPRAT V1.0 RESOURCE COUNTS FOR BOTH OPTIMIZED MEDICAL SETS

IMM quantity		Resource	MEDPRAT quantity	
9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set		9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set
1	1	Moxifloxacin (Avelox), 0.5%, 3-mL bottle	1	1
2	1	Mupirocin (Bactroban®[29]), 2%, 22-g tube	2	1
0	0	Nasal airway, 6 mm	0	0
0	0	Nasal airway, 7 mm	0	0
1	1	Nasal packing (posterior nasal packing)	1	1
0	0	Needle (23G)	0	0
1	1	Needle (25G)	2	2
1	1	Needle driver (AA)	1	1
0	0	Needle plastic	0	0
0	0	Nitrile gloves (large, medium, and small) (pair)	0	0
10	10	Nitroglycerin tablet, 0.4 mg	10	10
0	0	Nonstick bandage (Telfa®[30] pads)	0	0
2	2	Nylon suture, 2.0	1	1
0	0	Nylon suture, 5.0	0	0
0	0	Oral airway	0	0
1	1	Otoscope handle	1	1
1	1	Otoscope head	1	1
1	1	Otoscope USB cable	1	1
0	0	Oxygen mask—resuscitation mask	0	0
0	0	Oxygen tubing	0	0
1	1	Panoptic ophthalmoscope	1	1
1	1	Penlight	1	1
6	6	Pepto-Bismol®[31], 262-mg chewable tabs	6	4
4	4	Phenergan®[32] (promethazine tablet), 25 mg	10	10
4	4	Prednisone, 20 mg	16	16
0	0	Prilosec, 20 mg	45	45
2	2	Promethazine injectable (Phenergan®), 50 mg/mL single-dose vial	12	12
0	0	Proparacaine eye drops, 0.5%, 15-mL bottle	0	0
0	0	Provigil®[33] (Modafinil) 200-mg tablets	0	0

[29]GlaxoSmithKline LLC
[30]KPR U.S., LLC
[31]The Procter & Gamble Company
[32]Rising Pharma Holdings, Inc.
[33]Teva Pharmaceuticals International GmbH

TABLE XVIII.—COMPARING IMM AND MEDPRAT V1.0 RESOURCE COUNTS FOR BOTH OPTIMIZED MEDICAL SETS

IMM quantity		Resource	MEDPRAT quantity	
9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set		9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set
1	1	Psychotherapy	1	1
6	6	Refresh®[34] artificial tears (carboxymethylcellulose), 0.5%, 0.4-mL bottle	6	5
0	0	Refresh® eye ointment (petrolatum white and mineral oil), 42.5%; 57.3%, 3.5 g	0	0
0	0	Robinul® [35](glycopyrrolate), 0.2 mg/mL	0	0
0	1	Rocephin®[36] (ceftriaxone), 1 g	0	0
0	0	Rolled gauze	0	0
0	0	Saline nose spray, 22-mL bottle	1	1
1	0	SAM®[37] splint—leg/arm splint	1	0
1	1	Scalpel number 11 (scalpel blade and handle)	0	0
0	0	Scissors—trauma	1	1
0	0	Sharps container	0	0
0	0	Silver nitrate stick, 75%/25%	2	1
1	1	Skin staple remover	1	1
1	1	Skin stapler	1	0
1	1	Smooth forceps	1	1
0	0	Space anticipation glasses	0	0
1	1	Space station eye wash	1	1
0	0	Sterile gloves (large, medium, and small) (pair)	0	0
0	0	Sterile water, 10-mL vial	0	0
1	1	Stethoscope	1	1
0	0	Stethoscope earpieces	0	0
0	0	Suction cartridge	0	0
1	0	Suction device	0	0
0	0	Suction device collection bag	0	0
1	0	Suction device syringe	0	0
0	0	Suction tip—mouth (curette)	0	0
0	0	Suction tubing—endotracheal tube	0	0
0	1	Suction tubing—gastric tube	0	0

[34]Allergan, Inc.
[35]Wyeth LLC
[36]Hoffmann-La Roche Inc.
[37]The Seaberg Company, Inc.

TABLE XVIII.—COMPARING IMM AND MEDPRAT V1.0 RESOURCE COUNTS FOR BOTH OPTIMIZED MEDICAL SETS

IMM quantity		Resource	MEDPRAT quantity	
9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set		9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set
0	0	Sudafed®[38] (pseudoephedrine), 30 mg	0	0
6	6	Sudafed® 12-hour (pseudoephedrine), 120 mg	30	28
0	0	Surgical lubricant	0	0
0	0	Surgical tools kit	0	0
0	0	Suture scissors (BB)	0	0
3	3	Syringe (10 cc)	2	2
0	0	Syringe (35 cc)	0	0
2	2	Syringe (3 cc)	16	16
0	0	Syringe (5 cc)	0	0
1	1	Syringe (60 mL)	0	0
10	10	Tamsulosin, 0.4-mg tablet	10	10
0	0	Temporary tooth filling	0	0
0	0	Thermometer	0	0
0	0	Tobramycin and dexamethasone, 0.3%; 0.1%, 10-mL bottle	0	0
0	0	Tongue depressor	0	0
0	0	Tonometer	0	0
0	0	Tonometer tip cover	0	0
0	0	Toothed forceps (EE)	0	0
4	4	Toradol®[39] (ketorolac), 30 mg/mL, 2-mL single dose vial	3	3
1	1	Tourniquet	1	1
0	0	Tropicamide, 1%	0	0
91	96	Tylenol®[40] (acetaminophen), 325 mg	105	100
3	2	Ultrasound gel	2	2
0	0	Ultrasound machine	0	0
2	1	Urinary collection bag (leg bag)	2	1
0	0	Urine catheter—coude	0	0
0	0	Urine catheter—Foley	0	0
3	3	Urine catheter—short	2	2
3	3	Urine catheter—straight	2	2

[38]Kenvue Inc.
[39]Neumentum Inc.
[40]Kenvue Inc.

TABLE XVIII.—COMPARING IMM AND MEDPRAT V1.0 RESOURCE COUNTS FOR BOTH OPTIMIZED MEDICAL SETS

IMM quantity		Resource	MEDPRAT quantity	
9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set		9.07-kg mass-constrained medical set	9.07-kg mass- and 13,721-cm^3 volume-constrained medical set
9	9	Urine Chemstrips®[41]	9	10
0	0	Urine color chart	0	0
21	21	Valacyclovir, 1-g tablet	29	33
1	1	Valium®[42] (diazepam), 5 mg/ml, 2 ml syringe	1	1
1	0	Variable oxygen system	0	0
36	36	Vicodin HP®[43] (hydrocodone/acetaminophen HP), 10 mg/660 mg	30	30
0	0	VOS intubated patient hardware (ventilator/respirator)	0	0
0	0	Water	0	0
0	0	Wound packing	0	0
4	4	Zantac®[44] (ranitidine), 150 mg	4	4
0	0	Ziprasidone (Geodon®[45]), 20 mg/mL)	0	0
12	12	Zithromax®[46] (azithromycin), 250 mg	6	6
12	12	Zofran®[47] (ondansetron), 8-mg tablet	6	6
20	20	Zoloft®[48] (sertraline), 50 mg	21	21
0	0	Zyrtec®[49] (cetirizine), 10-mg tablet	0	0

4.0 Conclusion

In this report, it was first ascertained for verification purposes that the Integrated Medical Model (IMM) and Medical Extensible Dynamic Probabilistic Risk Assessment Tool (MEDPRAT) V1.0 and V2.0 results for the mean number of condition occurrences are similar across all three models. The mission-level metrics across all three models were then compared to juxtapose the total medical events (TME), crew health index (CHI), removal to definitive care (RTDC), and loss of crew life (LOCL) outcomes and verify their similarity in these risk metrics. Next, resource consumption by category was analyzed to ensure that the different models exhibit comparable values. Lastly, the authors looked at optimizing the medical sets produced by both models with mass and volume as constraints and observe the risk metric outcomes resulting from each set within a simulated Orion mission. Overall, the consistent similarity was noted in the mean values of condition occurrence, mission-level metrics, and mean values

[41]Roche Diagnostics Operations, Inc.
[42]Atnahs Pharma UK Limited
[43]ABBVIE INC.
[44]Boehringer Ingelheim Pharmaceuticals, Inc.
[45]Viatris Specialy LLC
[46]Pfizer Inc.
[47]Sandoz AG
[48]Viatris Specialy LLC
[49]Kenvue Inc.

of resource consumption by category across all three models, and where differences in the outcomes arise, they are also in accordance with known model assumptions and implementation differences. The comparisons here also demonstrate MEDPRAT V2.0 has differences with IMM, larger than those of MEDPRAT V1.0 with IMM due to its more appropriate underlying assumptions for long-duration spaceflight and enhanced feature capabilities, but these differences are still small, being within the IMM confidence intervals or on the same order of magnitude. When looking at MEDPRAT V2.0 predictions, one can see how the same basic principles implemented with a logical structure more befitting long-duration space travel affect the outcomes, especially in the untreated scenario and in resource consumption. The understanding developed by these comparisons provide an insight as to how updated model assumptions andg1 additional features may affect model results. In addition, for the Orion mission, the optimized medical sets generated by MEDPRAT provide lower risk outcomes than those generated by IMM across all mission-level risk metrics for both the mass-constrained and volume- and mass-constrained medical sets, although both the MEDPRAT and IMM optimized medical sets perform similarly overall. Thus, the conclusion is that MEDPRAT V1.0 and V2.0 produce results very comparable to IMM, while also incorporating additional fidelity, assumptions, and enhanced capabilities more consonant with the requirements and mission planning in long-duration spaceflight.

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