RECOMMENDATIONS AND CONCLUSIONS

RECOMMENDATIONS

Recommendation 1 (regarding NASA's proposed space radiation health standard):

NASA should proceed with the proposed approaches to revising the space radiation health standard. As proposed by NASA, the agency should:

- Apply a single space radiation standard to all astronauts;
- Utilize the most protective approach in setting the space radiation standard;
- Set the standard as a dose limit; and
- Utilize the mean value of the risk distribution based on 3 percent risk of exposure-induced death.

In implementing this recommendation, NASA should make explicit the agency's own ethical and policy analysis justifying the revisions to the proposed standard.

Recommendation 2 (regarding NASA's proposed space radiation health standard):
In the near future, NASA should re-examine whether to use risk of exposure-induced death (REID) or other metrics, or a combination of metrics, in setting the dose-based space radiation health standard. NASA should conduct an independent analysis of the validity of 3 percent REID and make explicit the agency's justification for the metrics it chooses.

Recommendation 3 (regarding strategies for communicating individual radiation-induced cancer risks):

To inform astronauts about their radiation risk, NASA should provide all astronauts with an individual radiation risk assessment and revise the risk communication system (i.e., the traffic light) for the updated space radiation standard to do the following:

- Assess and communicate the radiation risk at an individual level (as opposed to generic risk assessments) for all astronauts independent of the actual or projected radiation exposure and risk.
- Communicate the mean value of the risk estimate associated with an astronaut's radiation exposure.
- Communicate the uncertainties for the risk distribution using both uncertainty intervals and limits, and visual representations of the risk distribution such as probability density curves, histograms, or heat maps.
- Address specific questions and concerns that individual astronauts may have regarding their overall health risks following communication of their actual or projected radiation dose, and help them place radiation risks into perspective compared to other mission risks and their baseline risk of developing cancer.

Recommendation 4 (regarding strategies for communicating individual radiation-induced cancer risks):

NASA should communicate a comprehensive picture of an individual astronaut's cancer risks due to radiation exposure, beyond the information contained in the traffic light system. To do so, NASA should do the following:

- Respond to questions from astronauts regarding their total radiation exposure, and help astronauts put their radiation-induced cancer risk in context.
- Continue to discuss any changes in radiation risks as part of routine health briefings for the astronaut office, crews, and individual astronauts.
- Provide astronauts with an up-to-date resource on their radiation risks that they can access outside of formal meetings with NASA's Office of the Chief Health and Medical Officer.

- Provide astronauts with easy access to summary information regarding what is known about the cancer risk factors that might interact with radiation exposures to influence long-term health outcomes for astronauts.

Recommendation 5 (regarding NASA's waiver process):

NASA should develop a protocol for waiver of the proposed space radiation standard that is judicious, transparent, and informed by ethics. To avoid the perception that an exception to the standard is built into the space radiation standard itself, NASA should follow the ethics decision framework in developing a waiver protocol and it should provide supporting analysis and explanation justifying any waiver to the standard.

Recommendation 6 (regarding a risk communication research agenda):

NASA should conduct research to develop evidence-based risk communication and the agency should develop a radiation risk communication research agenda to fill knowledge gaps such as (1) what information astronauts want; (2) how astronauts process risk information; and (3) who/what are the most effective sources of information for astronauts. In addition, NASA should carry out research to examine and improve the effectiveness of its current and proposed risk communication strategies and materials.

CONCLUSIONS

The committee provided four conclusions based on its review and analysis of data and materials.

Conclusion I: The committee concludes that astronauts who travel on long-duration spaceflight missions are likely to be exposed to radiation levels that exceed the proposed new space radiation standard of an effective dose of 600 mSv. Unless technological advancements and engineering controls provide improved radiation shielding or other protections to astronauts, for a mission to Mars to proceed, NASA would need to seek waivers to the radiation health standard both for the mission and for each astronaut.

Conclusion II: NASA has proposed to use a traffic light color-coded system to categorize and communicate space radiation risks. Without empirically testing the traffic light color-coded system, there is insufficient information to determine whether it is an effective way for NASA to communicate the space radiation risks to astronauts. (For details, see Chapter 4 of the full report.)

Conclusion III: There are two concerns with the proposed traffic light system:

- At doses below the standard (i.e., in the green and yellow bands), there is insufficient clarity and detail about associated cancer risks.
- At doses above the standard (i.e., in the red band), inclusion of the waiver process suggests that an exception to the standard is built into the standard and its application.

Conclusion IV: The committee recognizes that NASA's inclusion of the waiver in its space radiation risk management process may be necessary to maintain the flexibility for the agency to pursue missions in which astronauts are exposed to radiation doses that exceed its standard. The committee concludes there is a need for an explicit and public framework for how NASA will consider both mission and individual waivers.

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