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Comment: Reply to Medical ethics of spaceflight should be based on ethical theories and include the non-ethical context

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We are grateful for the opportunity to respond to the recently submitted commentary engaging with our review article, *Medical Ethics of Long-Duration Spaceflight*. Scholarly critique is an essential part of developing sound ethical frameworks in this nascent and rapidly evolving field. We offer this reply to clarify several philosophical misinterpretations and respond to critiques that, in our view, reflect a misunderstanding of both our intentions and the scope of our article.

Discussion

Our review aimed to address an underexplored area of space medicine: the application of ethical principles to in-flight clinical decision-making during long-duration space exploration (LDSE). In doing so, we grounded our framework in the four-principle model of biomedical ethics—autonomy, beneficence, nonmaleficence, and justice—not as a moral theory, but as a pragmatic and pluralistic heuristic¹. This approach is widely used in clinical settings precisely because it reflects a diversity of moral commitments and values without prescribing a single ethical doctrine.

The commentary's assertion that our use of principlism reduces ethics to a form of risk–benefit analysis reflects a shallow and somewhat distorted reading of both the model and our article. Principlism is not a substitute for moral theory, but a tool for applying ethical reasoning in complex, real-world settings. It is rooted in widely shared moral norms and enables the weighing of *prima facie* duties—including when principles come into tension. Our article did not claim to resolve all possible ethical dilemmas, but rather to provide a structured framework for contextual decision-making, responsive to the realities of LDSE missions.

Further, the critique overlooks our explicit recognition of moral virtues such as fidelity, compassion, and conscientiousness, which enrich and support the principlist framework. We discussed the application of virtue ethics alongside our core structure and emphasised the need for ongoing reflection and the possibility of framework revision as space missions evolve. These points are either ignored or misrepresented in the commentary.

The commentary also objects to our treatment of the crew as a “single ethical unit,” suggesting this reflects an erasure of individual moral agency or a homogenisation of identity. We respectfully clarify that our focus was on the interdependence of astronauts in LDSE—where decisions made by or for one individual can materially affect the health, functioning, and survival

of others, as well as the mission itself. Ethical frameworks for such settings must, necessarily, accommodate both individual rights and collective consequences.

Regarding the call for greater engagement with feminist ethics, we agree that addressing inequity, exclusion, and structural injustice is essential in the broader space ethics discourse. However, we believe the commentary misrepresents the status of feminist ethics as a theory. Feminism is more accurately described as an ideological and interpretive lens through which existing ethical theories—including deontological, consequentialist, or virtue-based approaches—can be critically examined. While we did not explicitly adopt a feminist framework in our review, the principle of justice—as incorporated into our framework—provides an avenue to address issues of inclusion, equity, and the avoidance of structural harm.

Moreover, the application of feminist bioethics, while crucial to the design of fair policies around crew selection, institutional power, and representation, falls outside the clinical and in-flight decision-making domain that was the central focus of our article. We acknowledge that future work should expand on these broader sociopolitical questions, but such expansion should not be conflated with a failure of ethical reasoning within our stated scope.

The commentary further suggests that no adequate medical ethics framework can be built without a detailed engagement with normative ethical theories. While this may hold for broader philosophical inquiries, applied medical ethics has long recognised the legitimacy—and indeed the necessity—of pluralistic, context-sensitive frameworks that do not presume theoretical consensus. Notably, the Institute of Medicine's 2014 report, *Health Standards for Long Duration and Exploration Spaceflight*, adopts precisely this form of principlism-based framework to guide the National Aeronautics and Space Administration's own policies and decision-making in the context of uncertain health risks and limited medical capabilities². Our article builds upon and extends this precedent into the domain of in-flight clinical decision-making, a level of ethical guidance not explicitly addressed in that report.

We also wish to highlight that our paper was written under editorial constraints, including strict limits on length and references. We do not claim to have exhausted the literature nor to have provided a final framework. Rather, we intended to initiate structured reflection in a domain where practical ethical guidance is urgently needed and where current standards remain underdeveloped.

Conclusion

In conclusion, we value the philosophical perspective raised in the commentary, but we respectfully suggest it reflects a methodological divergence rather than a substantive flaw in our article. Our framework is intended as an applied contribution, grounded in widely accepted principles and enriched by moral virtues and contextual sensitivity. It is not a rejection of broader moral theory, but a recognition of the need for pragmatic ethical decision-

making in space medicine, particularly when human life, finite resources, and mission success are intertwined.

We hope this exchange fosters deeper interdisciplinary dialogue and that future work will integrate operational, clinical, philosophical, and sociopolitical perspectives to build a comprehensive and ethically robust foundation for long-duration human spaceflight.

Data availability

No datasets were generated or analysed during the current study.

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Author contributions

S.R. and V.C. wrote, reviewed and finalised the main manuscript.

Competing interests

The authors declare no competing interests.

Additional information

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