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Should the Carbon Footprint of Care be Taken into Account When Choosing a Treatment for Lymphoma? a Case Application on Mantle Cell Lymphoma

Max Piffoux[1], *Aurélie Cabannes-Hamy*[2], *Hajer Ben Souda*[3], *Olivier Hermine, MDPhD*[4,5], *Caroline Besson*[6]

[1] Service d'hématologie, Lyon Sud, Lyon, France
[2] CH Versailles, Le Chesnay, France
[3] CH de Versailles, Le Chesnay, France
[4] Imagine institute, Université Paris Cité, PARIS, FRA
[5] Hopital Necker, Paris, FRA
[6] UVSQ/Saclay/CH Versailles/INSERM CESP, Le Chesnay, France

OBJECTIVE
While climate change represents the greatest threat of the current century on human health, the carbon footprint of the healthcare sector represents 7-10% of occidental countries green house gas (GHG) emissions. Purchases, mostly of drugs and medical devices, represent about 50% of emissions. Oncology and hematology are suspected to be particularly carbon intensive, as they require long term and frequent consumption of healthcare resources. Here, we estimate the carbon footprint associated with different therapeutic strategies (including chemo-free or high dose chemotherapy) in patients with Mantle Cell Lymphoma (MCL) and discuss their future health impacts.

METHODS
Standard immunochemotherapy based versus chemo-free strategies were compared both in 1) the ≤65 years old/fit and 2) in the >65 years old/unfit populations. Namely, we compared 1) immunochemotherapy induction (rituximab, dexamethasone, cytarabine, and a platinum derivative) followed by autologous stem-cell transplantation and 3-year rituximab maintenance (LyMa) to obinituzumab, ibrutinib, venetoclax combination (OIV), and 2) rituximab, bendamustine combination (RB) to rituximab, ibrutinib combination (RI). These treatment schemes were considered to have similar clinical efficacy in each sub-group of patients.
Carbon footprints were estimated by considering drugs, medical devices, hospital stays, car journeys, medical biology and imaging consumption in the French context. Drug specific method (including production, packaging and transport with or without R&D, sales, general and administrative costs), and non-drug specific methods using mean emission factors based on their costs (kgCO2eq/€ from the French Environment Agency (ADEME) and the US Environmentally-Extended Input-Output (USEEIO) models) were applied to estimate drug carbon footprints and were compared in a sensitivity analysis. Carbon footprints were translated into future disability adjusted life years (DALY, a metric similar to quality adjusted life years QALY) expected to be lost in the future using the ReCiPe 2016 model.

RESULTS
The carbon footprint of each therapeutic strategy varied from 6.6 to 69.1 tCO2eq. In each, >70% of the total carbon footprint was related to drug purchase. A larger fraction (10-70%) of the carbon footprint of biotherapies (rituximab, obinituzumab) and low-cost small molecules (cotrimoxazole, valaciclovir) is related to their production while it is smaller (<10%) for high-cost small molecules (ibrutinib, venetoclax) that require higher R&D, sales, general and administrative costs.
In the ≤65 years old/fit population, treating a patient with LyMa leads to the emission of 16.8 tCO2eq corresponding to an estimated 0.21 [95%CI 0.08-0.51] induced DALY. Treating a patient with OIV for 5 years leads to the emission of 69.1 t CO2eq (0.86 [0.35-2.09] DALY) whereas stopping the treatment at 2 years leads to the emission of 36.6 tCO2eq (0.46 [0.19-1.11] DALY).
In the >65 years old/unfit population, treating a patient with RB leads to the emission of 6.6 tCO2eq (0.08 [0.03-0.2] DALY) while treating a patient with RI for 5 years leads to the emission of 41.1 tCO2eq (0.51 [0.21-1.25] DALY) whereas stopping the treatment at 2 years leads to the emission of 22.7 tCO2eq (0.28 [0.12-0.69] DALY).
These estimates have to be taken with caution, as they are highly dependent on the method chosen. Using non-drug specific ADEME or USEEIO mean emission factors increase the carbon footprint of 2 year OIV from 36.6 tCO2eq to 164 tCO2eq

and 313 tCO2eq, respectively. On the contrary, only accounting for drug production, packaging and transport diminishes its carbon footprint to 10.8 tCO2eq.
Detailed discussion on the models, on the impact of R&D and on the use of generic/biosimilar drugs will be provided at the congress.

CONCLUSIONS

Treatment of patients with MCL is associated with a significant carbon footprint. Integrating their carbon footprint in the therapeutic decisions (such as length of treatment) could lead to significant decreases in carbon emissions that could translate into less health damages to future generations. Drug specific carbon accounting methods seem more adapted than nonspecific ones to estimate the carbon footprint of high cost drugs . Future research is required to determine more precisely the carbon footprint of drugs and therapeutic strategies in patients with hematological malignancies.

Disclosures No relevant conflicts of interest to declare.

OffLabel Disclosure: Obinutuzumab and Venetoclax are part of a combination with Ibrutinib, that was reported to be efficient in young patients with MCL (ref OASIS trial). Bendamustine was shown to be efficient in first line treatment of MCL in the elderly (ref Rummel 2013).

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