Mapping the Climate Footprint of Clinical Research

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Abstract

This project estimated the greenhouse gas (GHG) emissions associated with the activities of multiple clinical studies sponsored by a major pharmaceutical company. Activities-based lifecycle assessments (LCAs) were conducted to determine the impacts of drug and study-related factors. The largest contributors to GHG emissions varied by study but were associated with the investigational product (IP), laboratory assessments, patient travel, and site monitoring visits, suggesting improvements to IP forecasting and supply, optimization of lab sample processing, and reduction of transportation emissions through decentralization of clinical trials as an improvement to sustainability.

Key Takeaways

- **Scientific and Strategic Value:** Identifying the drivers of GHG emissions in clinical trials is critical to informing sustainable trial design and product development. The data contribute to the goal of achieving Net-Zero clinical operations by 2045.
- **Impact on the Patient:** Taking a holistic view and recognizing the role of a clean environment on one's overall health, the data will inform how to ensure that the benefits of therapeutic development are not offset by harms to the environment.
- **Implications and Learnings for Others:** a framework for assessing environmental footprint in R&D will apply company-wide. These insights will also be shared with our vendors, CROs, sites, and industry peers to create a pre-competitive space for sustainability in drug development and drive broader reductions.

Introduction / Objectives

This research uses LCAs to measure the GHG emissions of a set of eight clinical studies sponsored by Janssen Pharmaceuticals that span all four phases of clinical development as well as multiple disease areas. The LCA was inclusive of clinical site utilities and other gaps observed in earlier research. It seeks to shed light on the GHG emissions of clinical research and discuss opportunities to reduce those emissions.

Materials / Methods

The LCAs examined eight clinical studies spanning multiple disease areas and clinical trial phases: Characteristics of these seven studies are highlighted in Table-1.

Table 1: Characteristics of the Seven Studies Analyzed

Phase	I	II		III			IV
Clinical Trial	TMC114HTX1002	77242113PSO2001	42756493BLC2002	54767414MMY3012	VAC18193RSV3006	R092670PSY3016	28431754DIA4032
Disease Area	HIV	Psoriasis	Urothelial Cancer	Multiple Myeloma	RSV	Schizophrenia	Diabetes
Number of enrolled patients	39	255	125	517	1,124	178	276
Number of sites	1	76	127	129	23	30	11
Number of involved countries	1	10	13	18	5	6	1
Number of investigational drug product kits produced	11	10,672	24,641	30,013	5,394	3,067	1,676
Number of laboratory samples shipped	3,335	56,129	46,086	120,268	35,439	1,098	1,09
Equivalent number of full-time sponsor employees supporting the study	2.52	18.2	46.7	115.2	15.2	29.3	2.0
Number of face-to-face patient visits	357	2,103	3,841	13,789	3,369	1,404	1,623

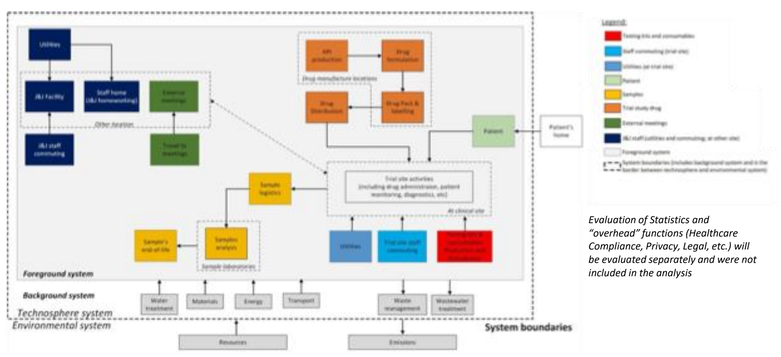
The analysis took an activities-based approach related to the investigational product (manufacturing (including APIs), and packaging and distribution) and to study conduct (e.g., recruitment, travel, material consumption and dispositioning of trial waste (see Figure 1)).

The LCA procedure included the following:

1. Creating a detailed map of all trial activities
2. Completing a materiality assessment
3. Collecting activity data
4. Sourcing or generating GHG emission factors for the activity data
5. Combining activity and emission factors to calculate the GHG emissions

The lifecycle assessments were conducted in accordance with ISO 14044 standards[1,2].

Figure 1: Map of Study Activities for LCA



Evaluation of Statistics and "overhead" functions (Healthcare Compliance, Privacy, Legal, etc.) will be evaluated separately and were not included in the analysis

Analysis / Results

The TMC114FD1HTX1002 study had the smallest emissions at 17,648 kgCO2e, while the 54767414MMY3012 had the largest emissions at 3,107,435 kg CO2e. Due to the disparity in number of enrolled patients across the study sample, we created a weighted-average for the contribution of each activity based upon the number of patients enrolled in the study. We excluded the TMC114FD1HTX1002 study as its emissions were not measured to the same granularity as the other studies. Looking at the weighted average, the largest contributors to the overall GHG emissions, driving 80% of the emissions across the clinical trial sample were:

- Drug Product where the manufacture, packaging and distribution drove 50% of trial emissions on average
- Patient Travel which drove an overage of 10% of emissions
- On-site Monitoring Visit Travel which driving 10% of emissions
- Sponsor Staff Emissions including their commutes to/from the office, emissions from sponsor offices and from sponsor staff working from home drove 10% of emissions

Figure 2: Percentage Contribution of Activities to the Average GHG Emissions of the Clinical Study Sample (excludes the phase-1 study as it was not measured to the same granularity)

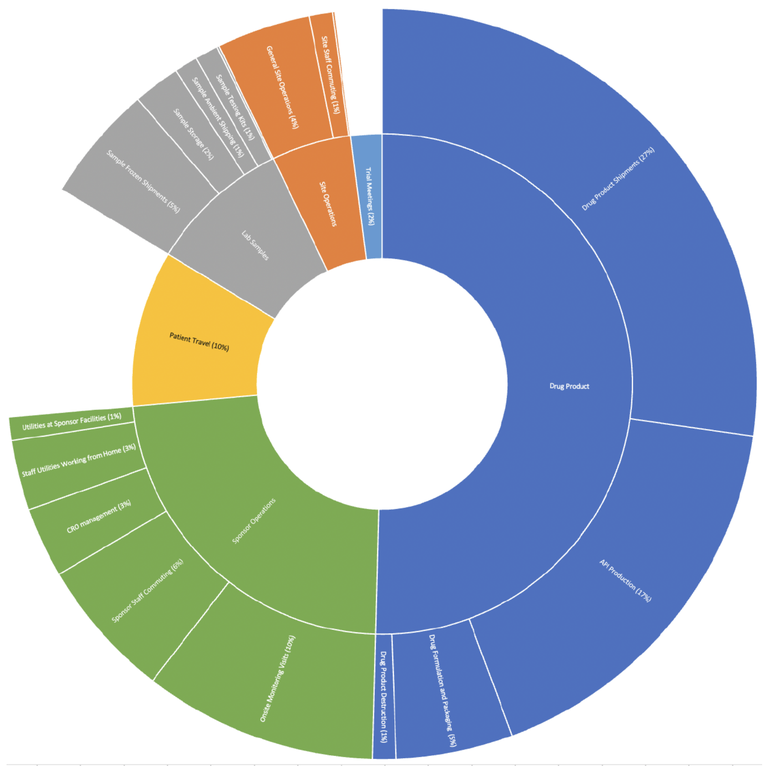


Table 2: Study Emissions (MT of CO_2-eq)

	Phase	I	II		III			IV	Average Value Weighted by Number of Enrolled Patients (excl. TMC114FD1HTX1002)
	Study	TMC114FD1HTX1002	77242113PSO2001	42756493BLC2002	54767414MMY3012	VAC18193RSV3006	R092670PSY3016	28431754DIA4032	
Total Study Emissions Kg CO2e[1]		17,648	579,674	1,145,213	3,107,435	358,675	207,788	171,043	798,211
Drug Product	Active pharmaceutical ingredient (API) production	890 [5%]	138,757 [24%]	12,382 [1%]	1,299,699 [42%]	6,001 [2%]	6,816 [3%]	50,255 [29%]	564 [17%]
	Drug formulation and packaging and labelling		26,313 [5%]	52,857 [5%]	161,838 [5%]	5,197 [1%]	18,464 [9%]	21,694 [13%]	171 [5%]
	Drug product shipments		87,704 [15%]	525,661 [46%]	226,593 [7%]	213 [<1%]	38,716 [19%]	29 [<1%]	868 [27%]
	Drug product destruction		2,231 [<1%]	6,413 [<1%]	27,282 [1%]	299 [<1%]	522 [<1%]	14.3 [<1%]	19 [1%]
Site Operations	Site Consumables	925 [5%]	147 [<1%]	769 [<1%]	2438 [<1%]	1229 [<1%]	98 [<1%]	116 [<1%]	2 [<1%]
	Site Operations		37,511 [7%]	62,815 [6%]	58,163 [2%]	12,535 [3%]	7,026 [3%]	14,483 [9%]	144 [4%]
	Site Staff Commuting		7,171 [1%]	9,599 [1%]	27,152 [1%]	18,093 [5%]	3,965 [2%]	1,333 [1%]	33 [1%]
Laboratory Samples	Sample Testing Kits	807 [5%]	6,008 [1%]	13,845 [1%]	26,389 [1%]	5,470 [2%]	0 [0%]	0 [0%]	32 [1%]
	Sample Ambient Shipments		9,070 [2%]	6,182 [1%]	26,672 [<1%]	3,293 [<1%]	0 [0%]	0 [0%]	23 [1%]
	Sample Frozen Shipments		46,978 [8%]	27,421 [2%]	224,312 [7%]	97,979 [27%]	0 [0%]	0 [0%]	154 [5%]
	Sample Analysis		4,135 [1%]	5,205 [1%]	13,428 [<1%]	4,447 [1%]	111 [<1%]	423 [<1%]	15 [<1%]
	Sample Storage		55,648 [10%]	8,896 [1%]	60,162 [2%]	73,122 [20%]	0 [0%]	0 [0%]	78 [2%]
Patient Travel		5419 [31%]	51,209 [9%]	97,058 [9%]	343,721 [11%]	52,364 [15%]	35,561 [17%]	42,443 [25%]	340 [10%]
Trial Meetings		26 [<1%]	1,963 [<1%]	2,731 [<1%]	136,451 [4%]	650 [<1%]	760 [<1%]	381.7 [<1%]	50 [2%]
Sponsor Operations	On-site Monitoring Visits	2560 [15%]	74,370 [13%]	119,628 [10%]	275,633 [9%]	51,361 [14%]	18,658 [9%]	26,767 [16%]	338 [10%]
	Sponsor Staff Commuting		13,851 [2%]	80,920 [7%]	85,345 [3%]	12,104 [3%]	44,367 [21%]	2,768 [2%]	189 [6%]
	Utilities at Sponsor Facilities	1,319 [7%]	3,217 [<1%]	6,025 [1%]	37,372 [1%]	5,773 [2%]	8,824 [4%]	4,893 [3%]	34 [1%]
	Sponsor Staff Utilities Working from Home		13,391 [2%]	24,338 [2%]	74,786 [2%]	8,544 [2%]	23,899 [12%]	5,442 [3%]	92 [3%]
	CRO management		0 [0%]	83,582 [7%]	0 [0%]	0 [0%]	0 [0%]	0 [0%]	111 [3%]

Strengths & Limitations

- Study limitations are associated largely with the available data, and the data gaps filled by proxy values or assumptions.
- Efforts were made to establish more representative proxy data and assumptions for the modelled system, but further primary data collection would be valuable in improving the robustness and accuracy of the study.
- Despite the limitations, overall, the assessment is a reasonable estimate of the impact and key drivers of impact for this subset of clinical trials.
- While the results of this study relate to the specific clinical trials assessed, if differences are acknowledged then it may be extrapolated in general terms to the design and operation of other clinical trials providing an indication of the environmental impact of broader industry-sponsored clinical research.

Discussion

Historically, LCAs of pharmaceuticals have been process or product-driven, either focusing on part of the pharmaceutical supply chain [3-5] or assessing the footprint of a product [6]. However, LCA boundaries have gradually expanded, and a new focus has emerged. This new area recognizes that pharmaceuticals as a product are just one element of a larger care pathway featuring healthcare provider (HCP) visits, hospitalization, and/or outpatient care [7-9]. A further limitation of this approach is that it has focused on typical care pathways in a commercial setting after a drug has received regulatory approval and has often neglected the environmental impact of clinical research required to bring those drugs to market.

Until recently, the few publications that assess the climate impact of clinical research [10] were of limited scope and/or include assumptions that do not align with our findings or the findings of other published research. They fall into two categories: those that underestimate the impact of patient travel, or those that neglect the impact of GHG emissions at the hospitals and clinics that serve as clinical trial sites.

For the former category, Lyle et al. [11] assumed that participant travel to and from the site was like that of a typical general practice in the UK, with travel of 2.4km for primary care and 17.4km for secondary care visits. This runs counter to other research where Borno [12] performed a retrospective analysis of the travel burden faced by 1,600 US-based cancer patients that participated in clinical trials and found the median roundtrip distance to be 83.04km. A second industry-led assessment of 600 participants [13], reported the median roundtrip travel exceeding 80kms, magnitudes greater than the assumptions of Lyle et al. [11].

The second category of publications [14-15] exclude GHG emissions at the clinical sites despite other research [8] and our own findings that site utilities contributed to more than 5% of overall average trial emissions, sometimes contributing to up to 10% of overall emissions for individual studies, making them a significant source of emissions.

The most comprehensive analyses found to date have been that of MacKillop et al [16] and the previous publication of the LCA results of the TMC114FD1HTX1002 study [17]. MacKillop et al examined the GHG emissions of three phase-3 clinical studies sponsored by Astra Zeneca. Both analyses thoroughly assessed patient travel and clinical site utilities and sought to create a comprehensive approach that would be replicated in future clinical trial LCAs.

Conclusions

In our analysis of the greenhouse gas emissions of seven clinical studies spanning multiple study phases and therapeutic areas, the six largest contributors of GHG emissions were: drug product (50% on average), patient travel (10% on average), travel for on-site monitoring visits (10% on average), and sponsor staff emissions (10%). Patient travel was the most consistent GHG hotspot across all seven studies contributing to 9% or more of emissions in each of our measured studies, as other hotspots appeared intermittently in some studies but not others, based upon differences in study design.

The knowledge gained from this exercise can be utilized in two ways:

1. Co-informing the design of new clinical studies to avoid or minimize reliance on hotspot activities
2. Guiding targeted action to reduce the GHG emissions of hotspot activities

Further, an activity-based approach is being pursued in collaboration with the Sustainable Healthcare Coalition to utilize emissions factors for individual study activities to predict the GHG emissions of new clinical study designs

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