



Sustainable
Markets
Initiative

THE DIGITAL SOLUTION FOR SUSTAINABILITY IN CLINICAL RESEARCH

HOW DIGITAL SOLUTIONS CAN REDUCE EMISSIONS
IN CLINICAL TRIALS

A REPORT BY THE SUSTAINABLE MARKETS INITIATIVE HEALTH SYSTEMS TASK FORCE,
IN COLLABORATION WITH BOSTON CONSULTING GROUP

PREFACE: THE SUSTAINABLE MARKETS INITIATIVE HEALTH SYSTEMS TASK FORCE

Sustainable Markets Initiative.

In his former role as His Royal Highness The Prince of Wales, His Majesty King Charles III launched the Sustainable Markets Initiative (SMI) at Davos in January 2020. The SMI is a network of global CEOs across industries working together to build prosperous and sustainable economies that generate long-term value through the balanced integration of natural, social, human, and financial capital. These global CEOs see themselves as the 'Coalition of the Willing' helping to lead their industries onto a more ambitious, accelerated, and sustainable trajectory. Read more [here](#).

Terra Carta.

In his former role as His Royal Highness The Prince of Wales, His Majesty King Charles III launched the Terra Carta at the One Planet Summit in January 2021. The Terra Carta serves as the mandate for the SMI and provides a practical roadmap for acceleration towards an ambitious and sustainable future; one that will harness the power of Nature combined with the transformative power, innovation, and resources of the private sector. Currently there are over 500 CEO-level supporters, including the first C40 city of Athens, Greece. The Terra Carta has served as the inspiration for the Terra Carta Design Lab. The Terra Carta is a roadmap for public, private, and philanthropic collaboration and open to all countries, cities, companies, organizations, and schools who wish to support it. Read more [here](#).

SMI Health Systems Task Force.

The SMI Health Systems Task Force was launched at the 26th United Nations Climate Change Conference (COP26) with the central aim of accelerating the delivery of net zero, patient-centric health systems that improve individual, societal, and planetary health. The public-private partnership brings together CEOs and leaders from AstraZeneca, GSK, Merck, Novo Nordisk, Roche, Samsung Biologics, Sanofi, the Karolinska Institutet, National Health Service (NHS) England, the Sustainable Healthcare Coalition, UNICEF, the University of Pavia, and the World Health Organization (WHO).

The SMI Health Systems Task Force is also a partner of the WHO's Alliance on Transformative Action on Climate and Health (ATACH), a platform that over 60 countries have committed to at the Minister of Health level to strengthen climate resilience and lower the emissions of health systems.

[↗](#) Additional information on the SMI Health Systems Task Force can be found [here](#).



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ABOUT THIS PAPER

The climate crisis is one of the most pressing risks to global health:^[1] rising temperatures are resulting in an increase in hospital admissions and heat-related deaths; extreme weather events such as flooding and droughts are disrupting food systems, displacing people, and undermining access to healthcare; and changing patterns of water-borne and vector-borne diseases are threatening decades of progress in infectious disease control.^[2] Climate change is also exacerbating the incidence of many non-communicable diseases (NCDs), including cardiovascular and respiratory illnesses, through increased air pollution, extreme heat, and other factors.^{[1][3]}

Climate change affects us all, but populations living in low- and middle-income countries are the most severely impacted.^[4] The health risks associated with climate change also disproportionately affect the most vulnerable and disadvantaged in our societies, such as children, displaced populations, and people with underlying health conditions.^{[1][4][5]}

Climate change causes millions of deaths every year – findings from 2019 indicate that over 9 million global deaths are attributable to air pollution^[6] and over 5 million deaths are associated with non-optimal temperatures.^[7] Limiting global warming to well below 2 degrees Celsius can avoid further impact on global health.^[8] Healthcare stakeholders must play their part by accelerating the delivery of patient-centric, equitable, net zero health systems.

The SMI Health Systems Task Force is committed to collaborating across and beyond the healthcare sector to drive concrete action to reduce emissions and propose targeted recommendations to health leaders worldwide. Its work is driven by the conviction that a whole system approach is needed to decarbonise healthcare, with targeted actions focused on product manufacturing and distribution, innovative clinical research and development, all the way to delivery of patient care.

This paper explores the role of digital health solutions in reducing healthcare emissions, with a specific focus on emissions created by clinical trials. It details the many ways digitalisation can support emissions reduction in clinical trials, using a real-world example to showcase the opportunity. Finally, it provides practical recommendations to accelerate the use of digital solutions in clinical research.

Additional perspectives on how to reduce emissions across health systems can be found in the associated white papers:

- **“Accelerating the Delivery of Net Zero Health Systems”** is an overview of practical recommendations and actions from the Task Force in support of net zero health systems
- **“Decarbonising Healthcare Supply Chains”** highlights how to reduce emissions across the supply chain, which is responsible for >50% of healthcare emissions
- **“Decarbonising Patient Care Pathways”** highlights how choices in patient care can drive emissions reduction

EXECUTIVE SUMMARY

Clinical trials represent up to 100 million tons of carbon dioxide equivalent (CO₂e) emissions per year, the equivalent of the yearly emissions of a country such as Belgium.^{[8][9]} ^a Showing how digital solutions can reduce trial emissions provides a robust test bed for how they can be deployed in broader clinical practice.

Benefits of digitalisation

Digital solutions are playing an increasingly important role in driving clinical trial efficiencies, reaching larger and more diverse participant groups, delivering improved patient outcomes, and reducing costs. They also have the potential to reduce emissions through:

- **Shorter trial timeframes**, enabled by the use of digital biomarkers, along with the use of data and artificial intelligence (AI) tools in trial planning, site selection, and patient screening and recruitment processes
- **Optimisation of trial employee work**, through end-to-end electronic data capture across clinical design to delivery and streamlined processes
- **Fewer trial participants**, due to the potential of synthetic control arms and digital twins^b
- **Reduced patient travel**, through decentralised trial setup and remote data monitoring
- **Increased patient recruitment and retention rates**, by using data to target relevant patients, through remote monitoring, and by making trials more convenient for participants

The emissions reductions driven by digital solutions in clinical trials generally outweigh their own carbon footprint, and there are further steps that can be taken to minimise this footprint (e.g. reusing and recycling of wearables, data storage optimisation).^{[10][11]}

Case Study

A landmark study in 2011 showed that digitally enabled clinical trials can reduce emissions by about 40% per year, using the CRASH 1 and CRASH 2 trials as examples. CRASH 1 evaluated the effect of corticosteroid administration on patient outcomes after traumatic brain injury, and CRASH 2 the effect of tranexamic acid administration in bleeding trauma patients. Both trials were conducted across over 40 countries and each of them included more than 10,000 participants. CRASH 2's design focused on reducing emissions using carbon reduction guidelines such as efficient data processing, participant recruitment, and reduced travel.

This study clearly pointed to the significant opportunity in deploying digital tools for emissions benefits. However, barriers remain to realising the full potential of digital solutions, and their sustainability benefits have not yet been comprehensively assessed.

^a. BCG analysis assuming 25% of "Other sectors and services" in Health Care Without Harm paper was R&D, corroborated by ~2% of emissions in US healthcare from "Testing and research" & ~1.5% for "research", in Health Care Pollution. ^b. A virtual model designed to reproduce a real-world person using clinical record to simulate how they would likely respond in a trial.

The evidence base and assessment methods to evaluate the benefits of digital solutions need to be further developed and refined. Therefore an agenda and funding plan for research, learning, and education should be formed.

Recommendations

To increase the adoption of digital solutions in clinical trials and reduce emissions, all stakeholders will need to act. For example:

- **Regulators** can encourage wider acceptance of the use of digital clinical trial solutions, aim for more international alignment on trial guidelines, and develop further guidance on the management of electronic interactions with patients
- **Research ethics** committees can set guidelines and provide recommendations on how digital tools can be used to improve patient experience and reduce trials' environmental impact, and advocate for the scale up of successful use cases
- **Trial sponsors** can develop common emissions measurement frameworks, set CO₂e reduction targets for trials, and incentivise clinical research organisations (CROs) to reduce emissions, including through the use of digital solutions. Sponsors can also offer clear guidance on recommended tools and digital infrastructure suppliers should invest in
- **CROs** can train employees to design and manage low-emission, decentralised trials, and enable participants to use digital tools
- **Digital solutions providers** can improve interoperability across digital trial tools by increasing the connectivity of data across solutions and optimising devices to allow the capture of multiple clinical datapoints to increase re-usability. Providers should also include emissions baselining and tracking functionalities in new digital solutions
- **Healthcare providers** can adopt digital trial solutions and upskill employees in the use of digital tools as part of broader efforts to increase healthcare digitalisation
- **Patient advocacy groups** can educate patients about the benefits of decentralised trials and the enabling role of digital tools

By bringing together leaders from across healthcare systems, the SMI Health System Task Force hopes to demonstrate practical steps and actions that can be taken to reduce greenhouse gas (GHG) emissions by using digital solutions in clinical trials. Private sector Task Force members will:



Commit to a **common framework by 2023** and subsequently start to **measure GHG emissions** in phase 2&3 clinical trials. Companies aim to report phase 2&3 trial emissions for trials starting in 2025



Align new trials to companies' **decarbonisation pathway** and **set trial emissions reduction targets** for 2030 at the latest



Incentivise clinical research organisations and clinical trial-related suppliers to **commit to a framework** to measure and **reduce emissions**, including through the use of digital solutions



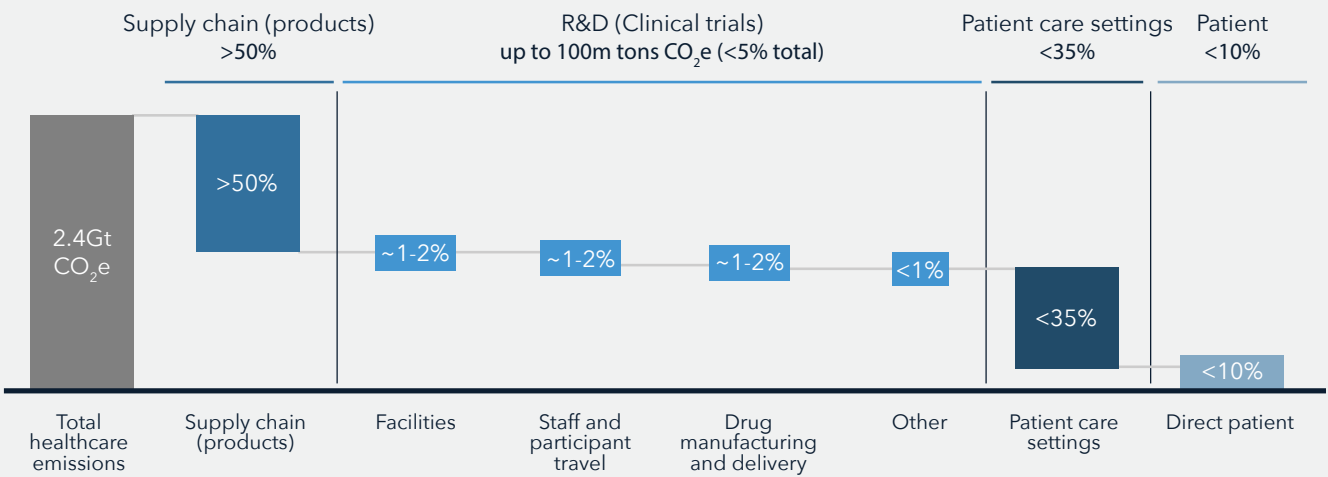
Target **90%+ of trials starting in 2025** to include a review of how **digital solutions can reduce emissions**

CLIMATE CHANGE: THE CHALLENGE FOR HEALTHCARE

The healthcare sector is responsible for about 4% to 5% of total global emissions,^[12] the equivalent of the 5th highest-emitting country in the world after China, US, India, and Russia.^{[8][9]} The ageing of the population, the rise of chronic non-communicable diseases, and rapid urbanisation all contribute to an increased demand for healthcare, challenging health systems to deliver care more effectively and sustainably.^{[13][14][15]} To achieve net zero, it is vital that all players – including manufacturers, governments, policymakers, regulatory bodies, health authorities, and payers – play their part in reducing emissions while improving health outcomes.

Health systems are complex, and their decarbonisation will require reducing emissions at each step of the value chain, including R&D, supply chain, and patient care. While most health care sector emissions are created in the upstream supply chain and in patient care settings, trial emissions represent up to 100 million tons of CO₂e per year, equivalent to a midsize country, such as Belgium (See Exhibit 1).

EXHIBIT 1 | Clinical trials drive up to ~100 million tons of CO₂e emissions per year



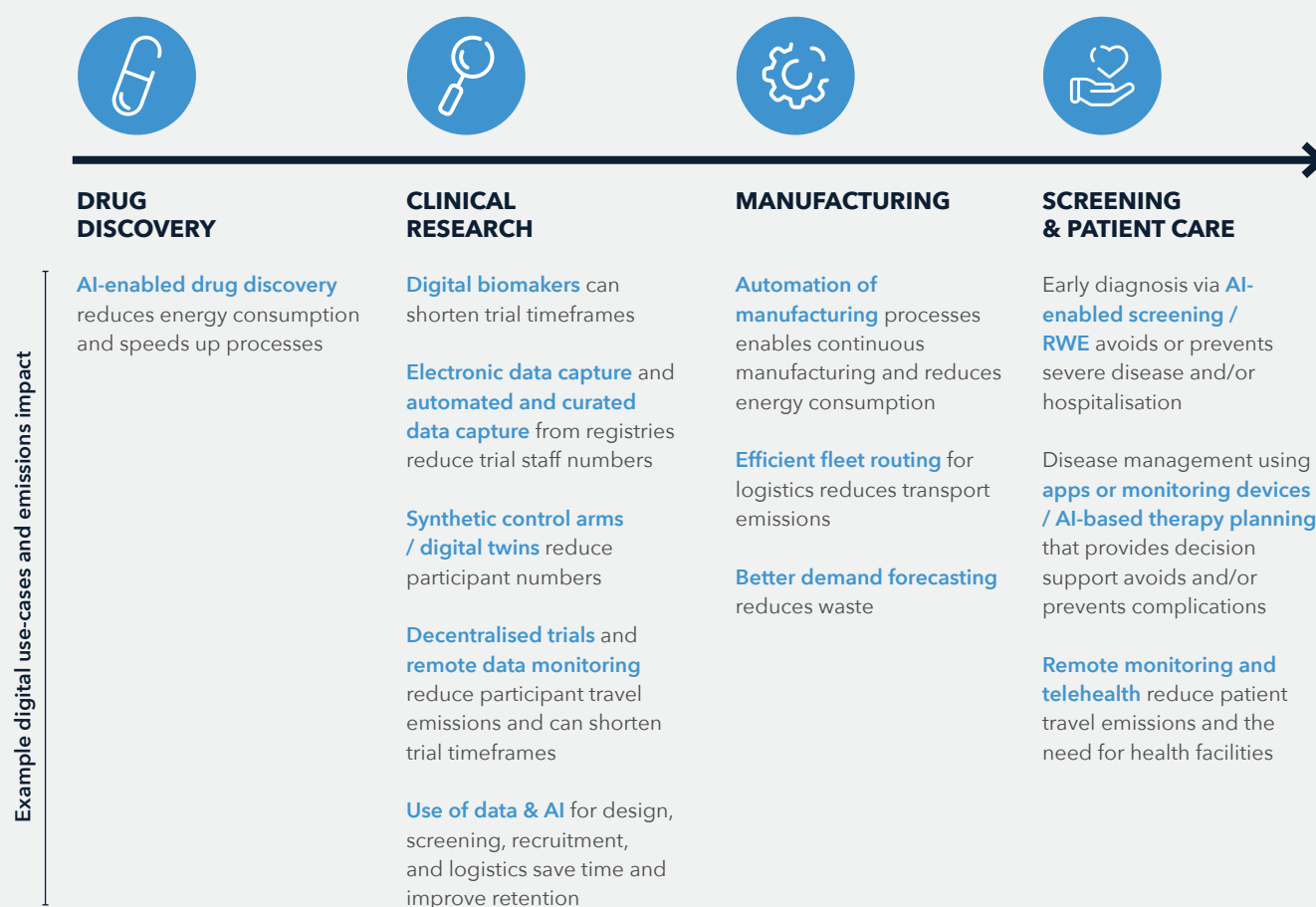
Source: Health Care Without Harm/Arup (2019); Health Care Without Harm/World Bank (2017); The Lancet Countdown on Health and Climate Change (2020, 2018); Carbon Cost of Pragmatic Randomized Controlled Trials: Retrospective Analysis of Sample of Trials (2009); The Carbon Footprint of Clinical Trials, News Medical, 2021; Towards Sustainable Clinical Trials, 2007; NIHR UK Carbon Reduction Guidelines 2019; Outsourcing Pharma, Reducing the Environmental Impact of Trials: A Comparison of the Carbon Footprint of the CRASH 1 and CRASH 2 Clinical Trials; BCG analysis based on literature review and case experience

This paper explores how digital solutions can help address clinical trial emissions. This would enable indirect benefits to public health by reducing the impact of climate change.

HOW DIGITALISATION REDUCES EMISSIONS

Digital solutions are playing an increasingly important role throughout the healthcare value chain in driving efficiencies, delivering superior patient outcomes, and reducing costs and emissions.^[16] (See Exhibit 2).

EXHIBIT 2 | Digital solutions can be used all along the healthcare value chain



Not exhaustive

Note: AI: artificial intelligence; RWE: real-world evidence

Source: BCG analysis based on literature review and case experience

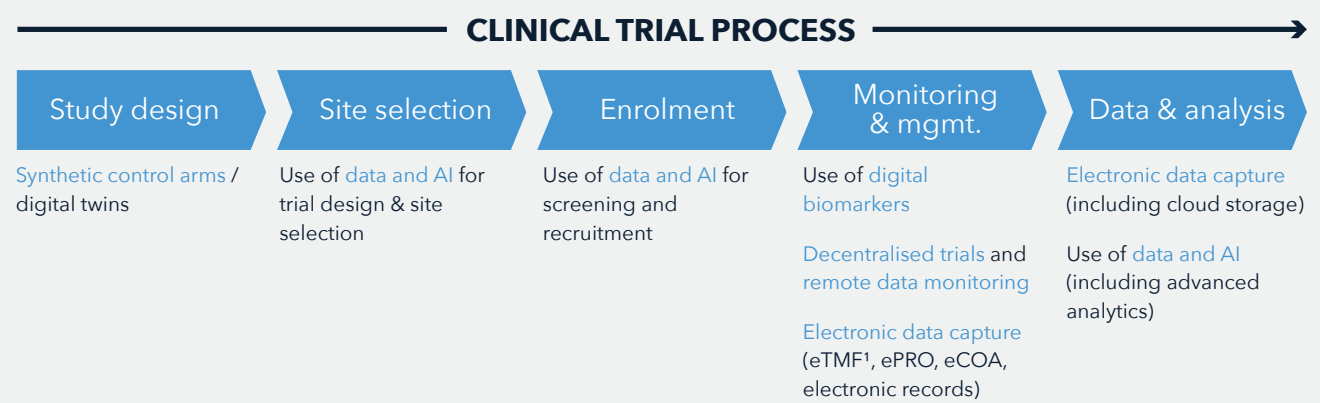
For the benefits of digital solutions to be realised, significant change is required within healthcare organisations, including employee upskilling, acceptance of digital tools, and management of risks related to patient safety. With the right measures in place, digital solutions can not only improve patient outcomes, but also reduce emissions (see *Decarbonising Patient Care Pathways* for additional details).^[10]

Digital solutions are a key enabler to reduce emissions related to clinical research. Because trials touch upon many aspects of the broader health system (including healthcare facilities, staff and patient travel, drug manufacturing and delivery), examining how digitalisation reduces emissions in clinical trials provides a good proxy for the benefits of digital in the broader healthcare system. Adoption of digital tools is also generally faster in clinical research and development, and their benefits can be examined under the controlled conditions of a trial setting.

THE DECARBONISING POWER OF DIGITALISED CLINICAL TRIALS

Digital solutions can be deployed across all stages of the trial process and the COVID-19 pandemic accelerated the availability and use of digital tools in the clinical trial setting at every stage of the trial process. (See Exhibit 3)

EXHIBIT 3 | Digital solutions exist for every stage of the trial process



1. Full set of documents required by regulators for a clinical trial

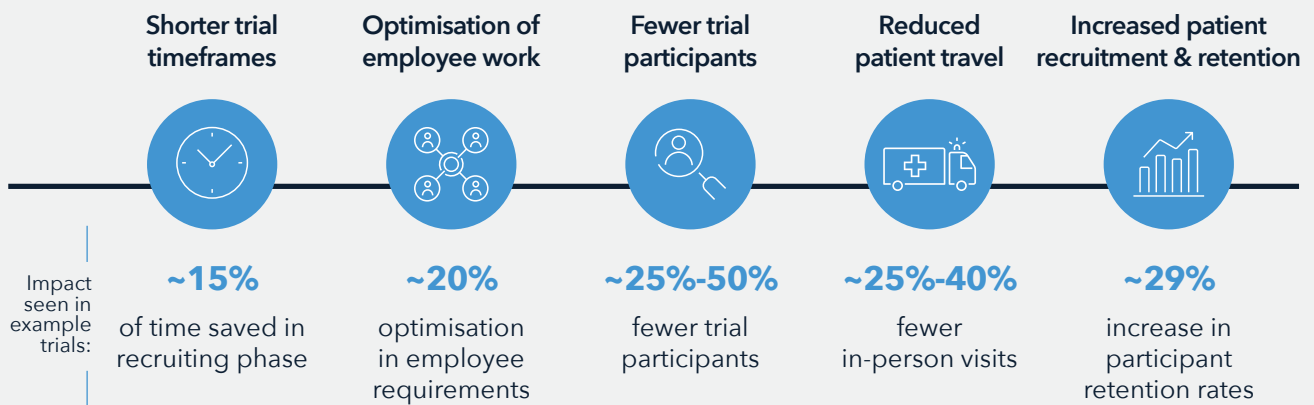
eCOA = electronic Outcome Assessment; eTMF = electronic Trial Master File; ePRO = electronic Patient Reported Outcome

Source: BCG analysis based on literature review and case experience

In 2022, 1,300 clinical trials are expected to include a virtual component supported by digital, a 28% increase vs. 2021.^[17] This is, however, still a small number compared to the total 37,000+ trials registered in 2021.^[18]

Adoption of digital solutions can reduce clinical trial emissions in five main ways. (See Exhibit 4)

EXHIBIT 4 | Five ways that digital trial solutions can drive emissions reductions



Disclaimer: Figures are based on specific trials and may not be applicable across all trials

Source: AstraZeneca, Sanofi, Science37, Unlearn, BCG analysis based on literature review and case experience

Shorter Trial Timeframes

Digital tools can accelerate clinical trials, allowing more trials to run in fewer facilities—a key source of emissions from electricity use and office waste.^[19] These tools can make trials available across a wider range of geographies, enabling greater diversity in data without a higher carbon footprint. There are clear time-saving opportunities at several key stages of the trial process:

Site Selection. Advanced analytics can streamline site selection by aggregating multiple data sets and providing evidence-driven recommendations on site effectiveness. This reduces the need to visit and audit multiple sites, thereby reducing emissions associated with travel. Sanofi is for example using advanced analytics to reduce the number of recruiting sites by 10%.^c AstraZeneca is also using advanced analytics to select sites by aggregating multiple data sets and these data driven sites recruit 16% faster compared to traditional site selection methods.^d

Screening and Recruitment. Digital recruitment can yield ~4x more participants per day of active recruitment versus offline strategies.^[20] Digital tools enable companies to aggregate patient data from multiple sources, target specific populations, and reach patients at home—all of which can accelerate and improve recruitment rates.^[21] Digital recruitment can also enable the reuse of patients' electronic health records.

^c. Based on internal company data. ^d. Based on internal company data.

A decentralised clinical trial for an at-home colon cancer screening test was completed in just seven months (and at 30% lower cost than traditional site-based recruitment).^[22] During the pre-study pilot, the virtual patient activation campaign yielded 3,724 candidates (of which 1,400 completed the study), while the traditional recruitment campaign which ran simultaneously at 6 separate gastroenterology offices yielded only 11 candidates. Another study examining patient screening showed that a clinical trial matching system took 24 minutes to screen 90 patients, compared with 110 minutes for manual eligibility screening.^[23]

Digital recruitment and screening not only reduce the patient travel required, but also help in selecting patients who are more likely to complete the trial. This thereby reduces wasted resources, which would otherwise contribute to emissions.

Optimisation of Employee Work

Electronic data capture and AI-driven automation methods can streamline processes and reduce staff requirements and workload, by eliminating repetitive tasks and reducing data entry errors. Sanofi has already automated 30% of the process to generate clinical study reports with rule-based solutions and is targeting automation of processes for 80% of all clinical documents with an additional machine-learning module.^e

Smaller Trials with Fewer Participants

Using digital solutions to generate synthetic controls (computer-generated control arms based on real-world evidence or historic data from similar trials) can reduce participant cohorts by 20% to 50%.^[24]

Alternatively, placebo group participants can be replaced by digital twins that use clinical records to simulate how they would likely respond in a trial. Providers of digital twin solutions suggest an average 12% to 25% reduction in trial participants can be achieved, with a 40% reduction in placebo group participants observed in some studies.^{[25][26][27][28]}

Digital solutions can also be used to capture clinically relevant diary events that can be used to create composite endpoints at which treatment efficacy is evaluated. A study by AstraZeneca on Chronic Obstructive Pulmonary Disease (COPD) that used digital solutions and composite endpoints^[29] resulted in a trial design that needed 50% less patients and 50% less visits than traditional COPD studies, leading to better patient experience. The novel trial design also reduced costs by 30% and trial duration by 15%.^f

Overall, trials with fewer participants save emissions from travel, as well as site-related emissions (e.g. energy, staff emissions) and logistics.

^e. Based on internal company data. ^f. Based on internal company data.

Reduced Travel for Participants and Staff

Remote data collection, using wearables, and telemedicine can reduce the need for onsite visits and participant and staff travel. This can reduce emissions by approximately 20% to 30% based on internal studies. For example, AstraZeneca reviewed 90 internal trial protocols and determined that 70% of trial data could be collected from home. Visits could therefore be reduced by 25% to 40% without diminishing the standard of care, which could lead to up to 28% less emissions.^g Sanofi also estimated that remote data collection in hybrid trials could reduce patient touchpoints by 25% to 40%, and onsite visits by 50% to 70%. This reduced overall trial emissions by 20% to 30%, largely through savings on transport-related emissions.^h Centralised monitoring of clinical trials has long been accepted by regulators and became a mainstay during COVID-19. It is, however, critical to adopt a risk-based approach and include in-person visits to facilities in case of any suspicions about data integrity.^[30]

Increased Patient Recruitment and Retention

One of the most common challenges in clinical trials is patient recruitment, enrolment, and retention. Challenges to recruitment and high dropout rates can impact the size and diversity of the patient cohort, and affect trial conclusions as well as endanger regulatory approval - only 42% of trials achieve their recruitment target.^{[31][32]}

Decentralised trials, enabled by digital trial solutions, reduce travel costs and the level of commitment required of participants, enabling a wider audience to participate. They have been shown to increase patient retention rates in trials by up to 29%.^{[33][34]} Higher retention rates reduce waste in manufacturing supply and transportation of drugs, thus reducing trial emissions even further. These trials also increase the diversity of patients recruited, with cohorts more representative of the broader population.^[35]

The five main benefits of digital solutions listed above are not only applicable to randomised control trials, but also to real-world evidence (RWE) trials, which use real-world data related to patient health status. Real-world data can be collected from a number of sources, including electronic health records, claims and billing activities, as well as patient-generated data. These patient-reported outcomes (PROs) are increasingly gathered electronically using digital solutions, which facilitate reporting for patients. A systematic review of the use of ePROs revealed that they decreased the rate of patients who did not report outcomes from about 50% to 20%.^[36] Several digital tools also support efficient participant enrolment and data analysis in RWE trials.^{[37][38]}

Overall, the use of digital solutions is expected to have a significant impact on clinical-trial related emissions. However, these solutions also have a carbon footprint which needs to be considered:

- In decentralised or hybrid trials, high volumes of data are exchanged and can be stored for long periods of time, leading to high data storage related emissions
- Shipment of samples, products, and wearables to participant's homes can increase logistics-related emissions in decentralised or hybrid trials
- The production and use of wearables can also be emissions intensive

^g. Based on internal company data. ^h. Based on internal company data.

There is however increasing evidence that the emissions savings enabled by using digital solutions in healthcare outweigh their own environmental footprint, and specific measures can be taken to address digital solutions emissions (e.g. wearables re-use and recycling, storage optimisation).^{[10] [11]} For example, Sanofi found in an internal review that data storage related emissions, which can be considerable in remote/hybrid trials with high data volumes, could be reduced by 50% to 70% by limiting hot storage (e.g. on fast hard-drives), and archiving data not required for the trial itself in low-emitting cold storage (e.g. on slower hard-drives, or offline storage). At the same time, it is important to note that additional research needs to be done to confirm the emissions impact of using digital solutions in trial settings and that this impact may vary based on the trial design and the resources required.

REAL WORLD EXAMPLE: THE EMISSIONS BENEFITS OF DIGITAL

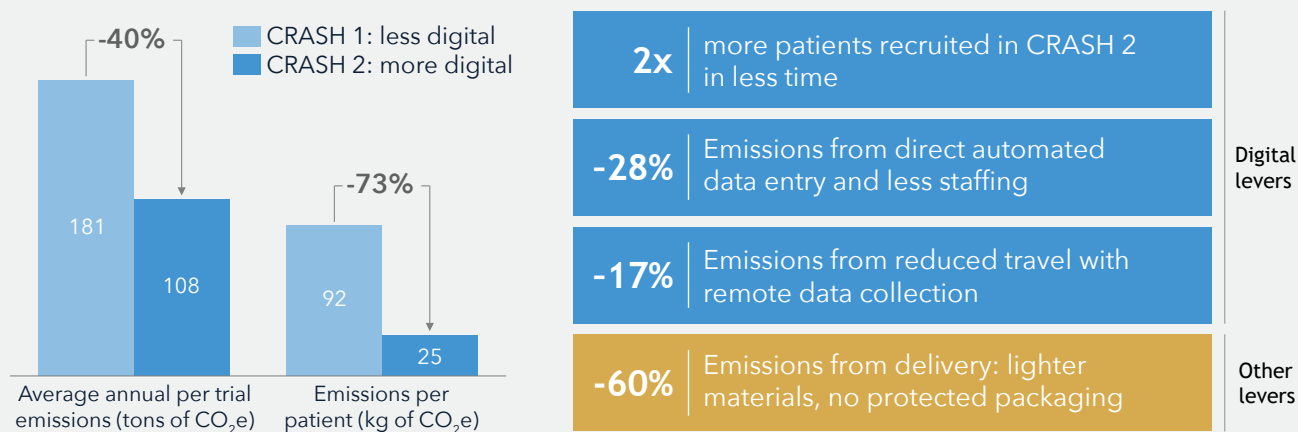
In 2011, a side-by-side emission audit was performed by the Edinburgh Centre for Carbon Management to compare the emissions of two clinical trials: CRASH 1 and CRASH 2.^[39]

CRASH 1 (April 1999 through May 2004) evaluated the effect of corticosteroid administration on patient outcomes after traumatic brain injury.^[40] The study was conducted across 49 countries and included more than 10,000 participants. The CRASH 2 trial (May 2005 through February 2010) examined the effect of tranexamic acid administration in bleeding trauma patients. It ran across 40 countries and included more than 20,000 patients.^[41] The design of CRASH 2 focused on reducing emissions using the UK's National Institute for Health and Care Research (NIHR) carbon reduction guidelines.^[42]

The CRASH comparison study was conducted over ten years ago and was focused on emissions from non-commercial clinical trials. The extent to which the principles can be applied in pharma-directed trials is open to question given the additional complexity and increased data collection, however the study provides insights on the impact of several clinical trial emissions reduction levers.

For both trials, emissions from the coordination centre, trial-related travel for hospital check-ups, and staff commutes—but not drug production—were compared. Overall, the CRASH 2 trial delivered a 40% annual emissions saving and 73% emissions saving per patient. (See Exhibit 5)

EXHIBIT 5 | CRASH study suggested CO₂e savings of ~40% per year and ~70% per participant, enabled (in part) by use of digital tools



1. Includes coordination centre (electricity, natural gas, steam, heating oil, water, waste); trial related travel (train, flights, accommodation); trial team commuting (train, bus, underground); freight delivery (air, diesel van)

Note: Data was collected on all elements that would generate emissions according to the greenhouse gas reporting protocol by the World Business Council for Sustainable Development (WBCSD). The energy consumption of the coordination centre was not obtained by direct measurement, which could lead to errors in estimation. The audit was for only one year and extrapolation to the entire trial may be inaccurate.

Source: Reducing the Environmental Impact of Trials: A Comparison of the Carbon Footprint of the CRASH 1 and CRASH 2 Clinical Trials (2011); Towards Sustainable Clinical Trials (2007); BCG analysis based on literature review and case experience

CRASH 2 reduced emissions through a range of levers enabled by digital solutions:

73%

Efficient recruitment led to 73% emissions reduction per patient

Coordinators recruited twice as many participants (more than 20,000) over a shorter timeframe (4.7 years versus 5.1 years) than CRASH 1. Faster patient recruiting in the CRASH 2 trial largely accounted for the increased carbon efficiency in terms of emissions per patient.

28%

Efficient data processing drove emissions reductions of 28% in the coordination centre

In CRASH 2, data was directly captured at the hospitals and sent via encrypted electronic data forms (instead of faxed, as in CRASH 1). This reduced the number of staff needed at the coordination centre by two full-time employees (FTEs), compared with the nine FTEs required in CRASH 1. Reducing trial staff decreases the associated travel emissions, and the need for office space, thereby cutting buildings-related emissions.

17%

Digital tools reduced travel-related emissions by 17%, as algorithms reduced the need for onsite data monitoring

The trial team in CRASH 2 also made use of digital teleconferencing and web-based trainings to reduce staff travel.

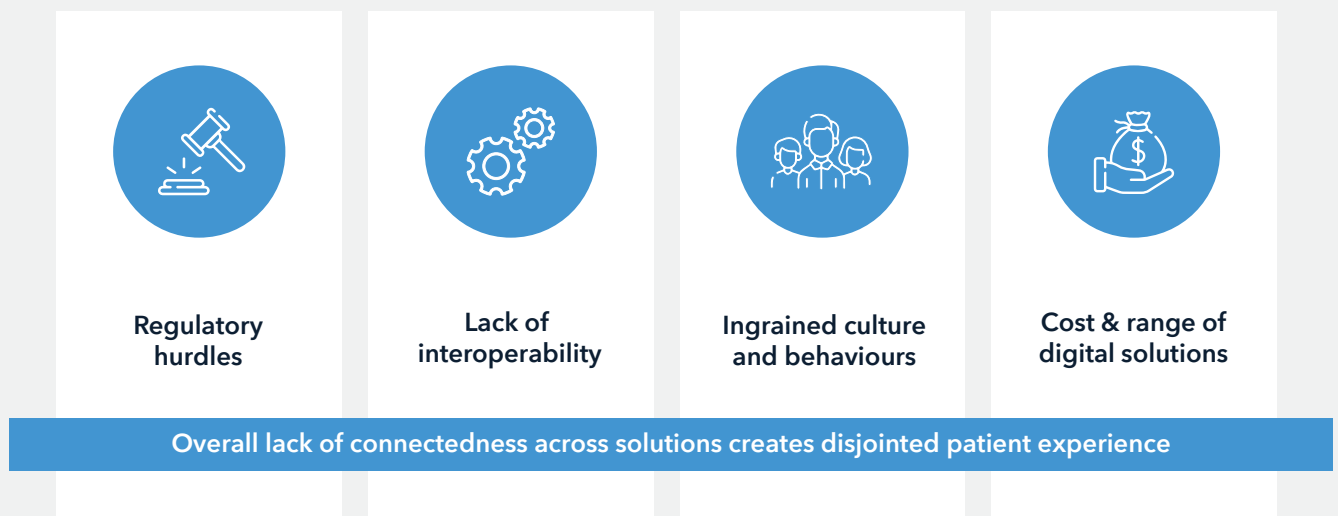
Beyond digital solutions, the smart redesign of trial packages drove 60% lower emissions in trial pack delivery. CRASH 2 used lighter primary packaging materials to reduce treatment weight to 2.5kg versus 9kg in CRASH 1. Although it was not used in this study, digital optimisation of logistics can often yield further emissions benefits.

Since the CRASH trials, little work has been done on the emissions benefits of digital tools in clinical trials despite the growth of digital solutions in clinical trials. This highlights the need for more focus on this important topic at the nexus of climate and health. There are now efforts underway to update the academic literature on this subject through the Sustainable Healthcare Coalition, but this remains a major gap in the evidence base at present.

BARRIERS TO DIGITALISING CLINICAL TRIALS

While COVID-19 accelerated digitalisation across clinical trials by limiting options for on-site travel, and creating a high unmet need for COVID-19 treatments, further efforts can be made across four key areas to increase the scale of digital solutions deployed for emissions benefits in clinical trials. (See Exhibit 6)

EXHIBIT 6 | Four areas where further work is required to scale digital solutions in clinical trials



Source: Pharmaceutical Technology; European Medicines Agency; NCBI; NIH Collaboratory; Nature; GreenPhire; BCG analysis based on literature review and case experience

Regulatory Hurdles

There have been major regulatory developments –accelerated by the COVID-19 pandemic–to enable greater use of digital solutions in clinical trials in recent years. For example:

- The US Food and Drug Administration (FDA) has a specific regulatory process to **address the use of digital biomarkers** (and their components) and is currently piloting a program that further streamlines product-level approvals.^[43] Meanwhile, the European Medicines Agency (EMA) has a set of qualification criteria that companies must follow to use a digital biomarker in a trial^[44]
- The FDA's 2021 draft guidance details **requirements for remote data acquisition from patients** in clinical trials, enabling decentralisation^[45]
- The FDA's Digital Health Centre of Excellence also provides **guidance on Software as a Medical Device, mobile medical applications, wireless medical devices, and digital health software precertification**^[46]
- Both the FDA and EMA published **guidelines for good clinical practice that enable greater use of risk-based monitoring principles**, paving the way for more remote monitoring of clinical trial data.^[47] The FDA has also confirmed that sponsors who have switched to remote monitoring during the pandemic do not need to re-monitor on site^[48]

Despite these developments, further guidance and acceptance from regulators are still required for digital solutions to be used widely in clinical trials and drive emissions benefits:

- **Requirements for digital tools are still evolving**
Experts are still debating topics such as the use of patient-relevant endpoints (in place of clinical outcomes) to indicate efficacy and the identification of patients that can be included in synthetic control arms. The FDA and EMA do not currently have official guidance on using digital twins and synthetic control arms in trials, although the FDA has issued an RWE framework and the EMA has recently issued a draft qualification on a statistical method (Prognostic Covariate Adjustment) that supports the use of synthetic control arms^[49]^[50]
- **Guidance on digital tools in clinical trials vary across geographies, limiting the ability of sponsors to implement global approaches**
Where clinical trials are intended to produce globally representative results, different regulator guidance on digital tools across geographies can be inefficient for sponsors of multicentre trials. For example, in the EU, the EMA's guidance on electronic consent (eConsent) requires the sponsor to clarify legality and compliance with each country's ethics committees and national regulatory authorities, making it challenging to conduct cross-broader trials with digital solutions^[51]

Lack of Interoperability Between Digital Solutions

To reap the benefits of digital solutions, it is vital that they work seamlessly together.^[52] However, digital tools remain complex to set up and are not always interoperable – with data often captured in nonstandard formats using local codes.^[53]^[54] This increases difficulty for trial managers, and negatively impacts patient user experience. It can also introduce errors that distort analysis, especially in large

data sets, thus eroding trust in digital health technologies. Although interoperability itself does not reduce trial emissions, it facilitates adoption and acceptance of the digital solutions that enable emissions savings.

Ingrained Culture, Behaviours and Beliefs

All those involved in trials—trial sponsors, providers, technology platform providers, CROs, and patients—need to learn how to work with new digital systems and devices. Major stumbling blocks in realising the benefits of these new digital tools include a reluctance to change behaviours and embed digital tools in the normal course of running clinical trials, concerns about data privacy and security, a lack of access to technology, and insufficient technical literacy.^[55]

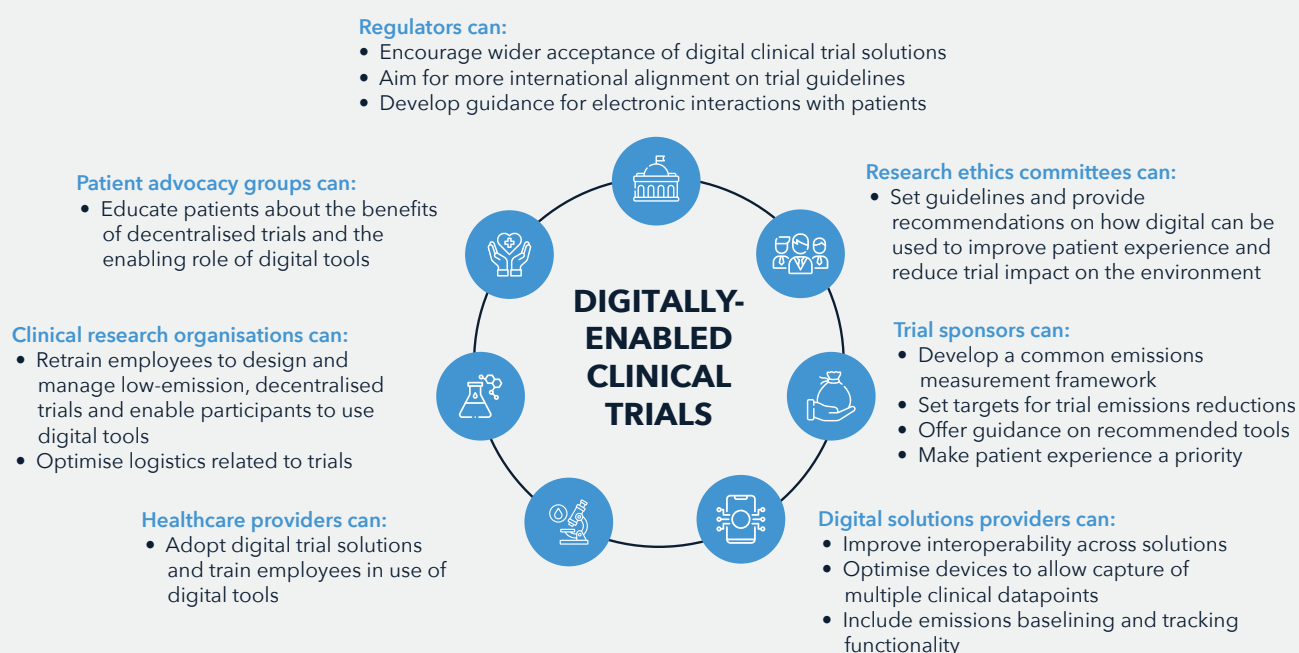
Cost and Range of Digital Solutions

Although digital solutions are expected to drive down the cost of clinical trials, technology remains expensive (particularly the initial investment), and with so many options to choose from, many providers are not sure which to invest in.^[53] A survey of 231 clinical trial sites finds that cost, complexity, and finding the right technology are the key challenges associated with digital adoption.^[54]

SCALING UP DIGITAL SOLUTIONS TO DRIVE TRIAL EMISSIONS REDUCTIONS

To accelerate the rollout of digital solutions as a key enabler of low-emissions trials, every stakeholder can act. (See Exhibit 7)

EXHIBIT 7 | The entire ecosystem can act to digitalise & decarbonise clinical trials



Source: BCG analysis based on literature review and case experience

Regulators, with input from clinical trial sponsors/registration applicants, can provide tailored recommendations on the use of digital tools as part of the scientific advice shared at trial submission. Regulators can also aim for international alignment on digital trial guidelines to facilitate global trials, and provide clear guidance on electronic interactions with patients, confidentiality, and privacy to increase comfort and acceptance of digital solutions among patients.

Research ethics committees can set guidelines and provide recommendations on how digital can be used to improve patient experience and reduce the environmental impact of trials, determine best practices, and advocate for scale up of successful use cases.

Trial sponsors can develop common frameworks to measure trial emissions and set targets to reduce them, and incentivise CROs to reduce emissions, including through the use of digital solutions. They can also offer guidance on tools and digital infrastructure CROs should invest in, and make patient experience a priority to increase trust in digital health solutions.

Digital solutions providers can improve interoperability across solutions to provide a simpler, smoother user experience. They can also optimise devices to capture multiple clinical datapoints to increase re-usability. As new digital tools are developed, providers can also include emissions tracking functionalities as standard to better measure trial emissions.

CROs can retrain employees to design and manage low-emission, decentralised trials and enable participants to use digital tools. They can also optimise logistics related to trials, using AI algorithms for smart shipment of laboratory supplies. CROs can also reduce package weight using digital tracking tools (e.g. QR codes instead of package inserts, where supported by regulatory authorities).

Healthcare providers can adopt digital solutions and train employees in the use of digital tools. For example, the NHS has a partnership with the ORCHA to provide employees with access to a Digital Health Academy.^[56]

Patient advocacy groups can educate patients about the benefits of decentralised trials and the enabling role of digital tools.

SMI HEALTH SYSTEMS TASK FORCE ACTIONS TO DIGITALISE AND DECARBONISE CLINICAL TRIALS

The SMI Health Systems Task Force recognises the key role digital solutions can play in reducing emissions across the healthcare sector, especially in clinical trials.

The Task Force private sector members, supported by public sector partners, are taking concrete action to digitalise and reduce emissions from clinical trials. They will:



Commit to a **common framework by 2023** (see Appendix) and subsequently start to **measure GHG emissions** in phase 2&3 clinical trials. Companies aim to report phase 2&3 trial emissions for trials starting in 2025



Align new trials to companies' **decarbonisation pathway and set trial emissions reduction targets** for 2030 at the latest



Incentivise clinical research organisations and clinical trial-related suppliers to **commit to a framework** to measure and **reduce emissions**, including through the use of digital solutions



Target **90%+ of trials starting in 2025** to include a review of how **digital solutions can reduce emissions**

The Task Force invites other healthcare stakeholders to join the effort to drive emissions reductions across the clinical development process and scale digital solutions. It hopes that the example it sets as a group will encourage others across the clinical research landscape, and broader healthcare sector, to take action in reducing GHG emissions to protect future public health.

SMI HEALTH SYSTEMS TASK FORCE CONTRIBUTORS

The SMI Health Systems Task Force thanks the members of the Task Force's Digital Health working group for their contribution to this whitepaper, and for their role in coordinating contributions from their organisations:



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APPENDIX: A FRAMEWORK FOR CALCULATING TRIAL GHG EMISSIONS

A consistent framework for calculating trial emissions across the healthcare industry is critical to better understand emissions hotspots and inform decarbonisation strategies.

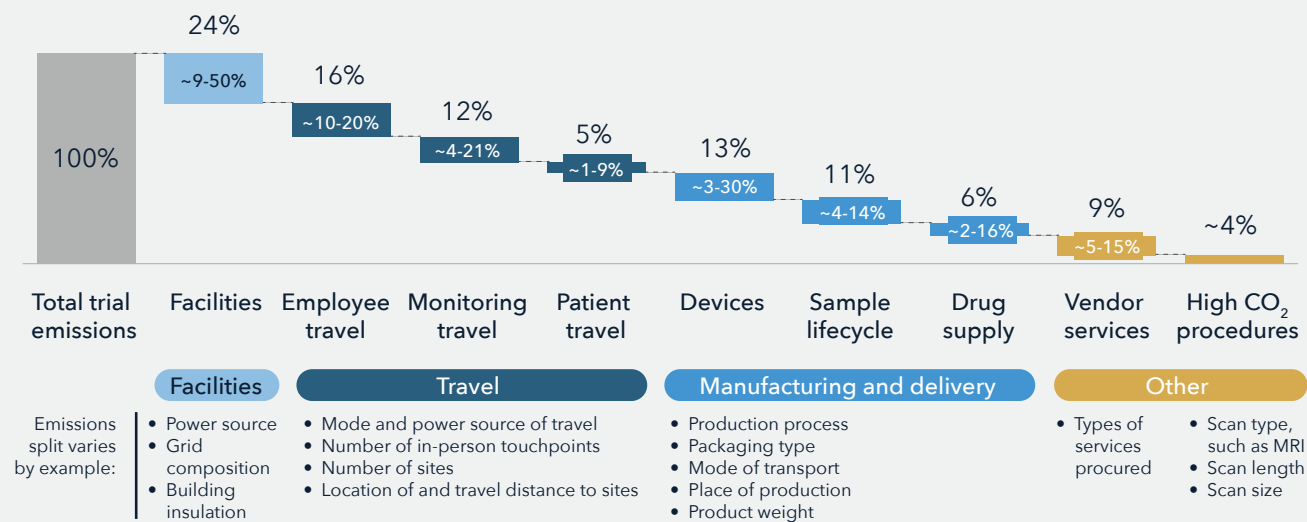
At a high level, four broad categories drive emissions in clinical trials:

- Facilities use - with emissions largely driven by electricity and heat related emissions
- Patient, clinician, and other staff travel
- Manufacturing and delivery of products
- Vendor services, or high emitting medical procedures (e.g. MRI scans)

Emissions driven by each of these categories can vary greatly depending on the trial design and set-up including the length of the trial, the number of participants, the type of drug, the number of sites, and the logistics solutions. As an example, Exhibit 8 below shows the variability in trial emissions recorded through a series of three AstraZeneca trials.

EXHIBIT 8 | There can be significant variation in the split of trial emissions

Emissions split per trial (% CO₂e) - average and range

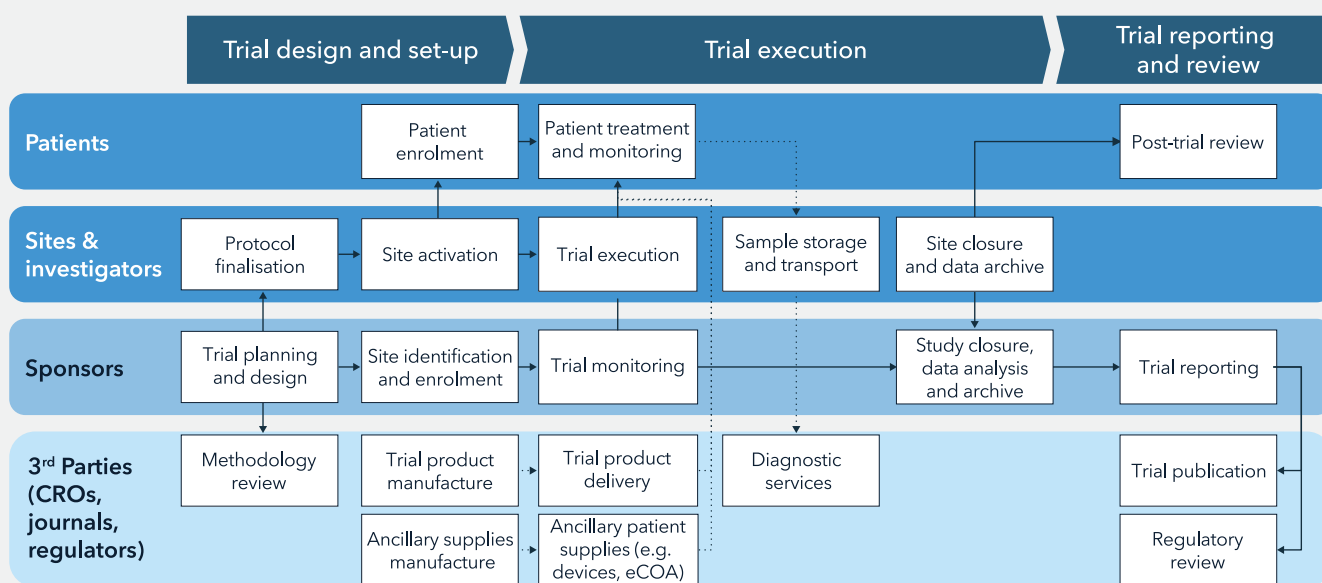


Source: Analysis of a sample of AstraZeneca clinical trials from cardiovascular, respiratory and oncology therapy areas running between 2017 and 2024; BCG analysis based on literature review and case

Having a standardised framework and easy to use, flexible tools to assess carbon emissions during the trial design phase are critical for stakeholders to assess trial footprint and identify opportunities to reduce emission without compromising on trial objectives. It is currently challenging to baseline, track, and assess the impact of initiatives to reduce emissions from trials given the lack of a consistent methodology used across the industry. To address this issue, the Sustainable Healthcare Coalition, in collaboration with members of the SMI Health Systems Task Force, and academics from the Clinical Trial Units in the UK, is creating a framework to quantify the carbon footprint of clinical trials. This framework will include a measurement methodology, as well as an Eco-Design tool – a calculator for clinical trial emissions. This will enable organisations to be able to document clinical trial footprints to compare, mitigate, and reduce emissions across trials.

While activities may vary based on the type of trial, Exhibit 9 below shows the typical set of activities within a trial for which emissions factors could be incorporated as part of the Eco-Design tool and overall emissions measurement methodology.

EXHIBIT 9 | Example of key activities undertaken during a clinical trial



Source: Sustainable Healthcare Coalition

While there are many types of clinical studies where the activities listed above would vary considerably, the tool will focus on typical interventional randomised clinical trials. There are three main types of trials that will be covered by the tool:

- **Conventional trials** where in-person site visits are conducted in the pre-trial phase and phone calls and visits to trial sites are used during the trial and post-trial phases
- **Hybrid trials** where in-person site visits are conducted in the pre-trial phase, remote digital monitoring and home nurse visits are used in the trial phase, and a mix of visits, digital tools, and phone calls are used in the post-trial follow ups
- **Decentralised trials** where telehealth appointments are conducted in the pre-trial phase, telehealth appointments and remote digital monitoring are used in the trial phase, and a mix of telehealth appointments, digital monitoring, and phone calls are used in the post-trial follow ups

As trials become more digital, emissions related to employee and patient travel tend to decrease and there is increasing flexibility in how to conduct patient interactions and sampling. However, the emissions related to packaging, transport, and IT resources tend to increase for remote trials. It is therefore critical to carefully assess each activity for the various types of trials to estimate the net impact of using digital tools on emissions.

There are two main methods that can be used to calculate emissions for each activity:

1. Activity-based method

This method uses bottom-up data for activities at each stage of trial (e.g. number of samples stored, patients treated, etc.) and combines this with emissions factors per unit of activity. Emission factors are either based on what is generated by the project or are sourced from academia or life cycle databases. This method tends to be more accurate and comprehensive in emissions measurement, but data can often be more challenging to collect

2. Spend-based method

This method uses cost information as a proxy measure for activities and then combines this with sector-specific emissions factors per unit of economic activity. While it is easier to implement, it is not always accurate. However, it can be used to rapidly fill gaps where activity data is absent or particularly challenging to calculate

Activity data and spend data could be collected from the records of completed, current, or planned trials and modelled in order to appraise their carbon footprint. The Eco-Design tool will use activity-based methods where possible and complement any data gaps with a spend-based method.

The Eco-Design tool and emissions measurement framework has been commissioned and is currently under development. The key stakeholders plan to ensure the applicability of the methodology and tool to publicly and commercially funded trials. The tool will be launched by the end of 2023 once the approach is developed and validated.

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