Understanding Carbon and Equity Hotspots in the Living Kidney Donor (LKD) Assessment Pathway

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Acknowledgements

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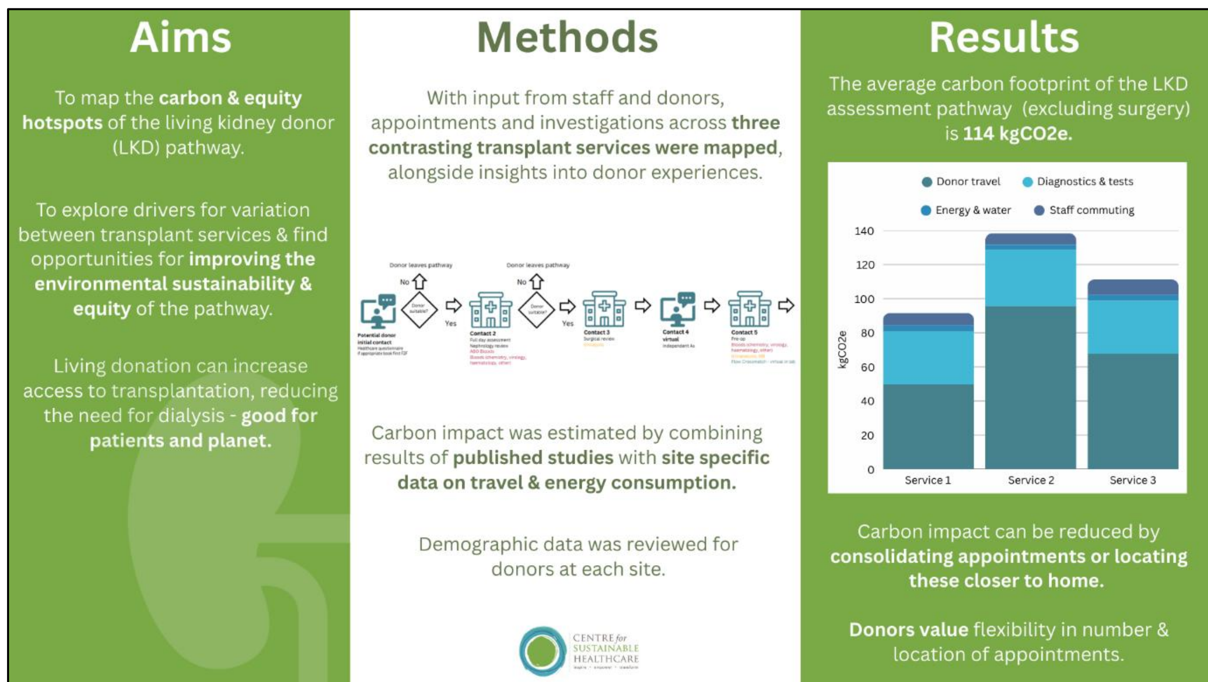
Section 1: Learning into Action Summary

Graphical abstract



A quick guide to implementing our findings into your service

- Experience of donor is key
- Any reduced-carbon model needs to be balanced with the needs of the donors
- If pathways are too inflexible donor drop off/experience potentially outweighs the carbon benefits
- Getting more donors onto and through the pathway means more donations and less dialysis – better for patients and good for the environment.
- Condensing investigations into fewer visits can speed up donation pathway
- Travel costs are the biggest contributor to the donor assessment carbon footprint

Step 1: Recruit and involve those with lived experience of donation in a pathway re-design group

Step 2: Understand the demographics and locations of your donors- look at past data

Step 3: Ensure testing follows national guidelines (link)

Step 4: Where possible reduce travel whilst allowing flexibility for those who want more face-to-face support

Step 5: Gather data to monitor impact of any changes overtime

Recommendations for commissioners

Increasing living donation will free up resources elsewhere by reducing demand for dialysis. Support transplant services to invest in improving kidney donor assessment - e.g. by securing capacity in radiology, cardiology, psychology to allow timely/coordinated investigations, or by overcoming financial barriers to carrying out investigations in local centres, closer to donors' homes.

Summary of findings

The average carbon footprint of the LKD assessment pathway (excluding surgery) is **114 kgCO2e.** The annual carbon footprint of dialysis is **3,800 kgCO2e**

Table 1: Carbon footprint breakdown for an average LKD assessment pathway

Activity data for average LKD assessment pathway	Total (kgCO2e)	Contribution
Donor travel	71.0	62
Blood & swab tests	19.5	17
Diagnostics	11.3	10
Staff commuting	7.7	7
Overhead energy & water	3.3	3
Urine tests	1.4	1
Transportation of blood & swab tests	0.0008	0.001
Total	**114.2**	

Collective goals

Collective goals for more people to successfully donate a kidney through LKD pathways:

1) Tools/principles are available which utilise our new knowledge base and help services reduce carbon costs
2) Clear exemplars show what differences these changes can make- a repository of ideas and tools
3) All services review their LKD assessment pathway *(in 2025/26)*
4) Those with lived experience co-develop these reviews to improve outcomes and experience of donors with the aim of increasing number of successful donations

Section 2: Project report

Introduction

The NHS has set a target of reaching net zero carbon emissions by 2045 and transforming care pathways is a crucial part of delivering against this goal. The living kidney donor pathway can lead the way.

Dialysis is a key carbon hotspot[1] and in 2019 (pre-Covid), there were 3,483 kidney transplants in the UK, of which 1,042 were from living donors. On average, people wait approximately 2 years for a transplant once listed, (2) during which time the vast majority will need to start dialysis; in 2019 only 8-9% of transplant recipients received pre-emptive transplants (i.e. before needing dialysis).

Living donor kidney transplantation can **increase the availability of kidneys for transplantation**, particularly in minority ethnic groups who may be less likely to find a match. However, currently the pathway for recruiting, screening and preparing someone to donate their kidney is variable between services, lengthy, and entails multiple journeys for investigations.

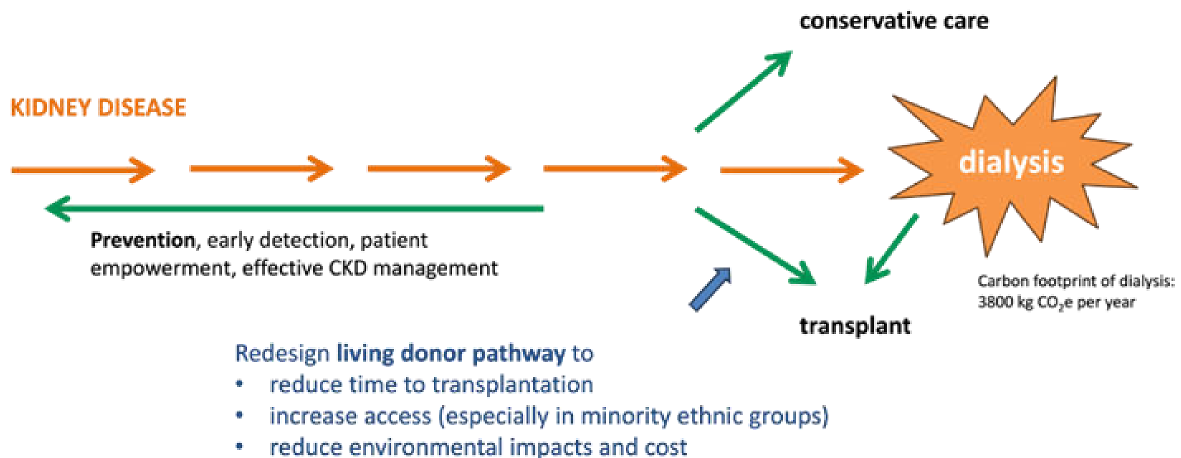


Figure 1: Strategies for reducing the carbon footprint of chronic kidney disease by avoiding the need for dialysis

Redesigning this pathway with staff and donors has the potential to improve equity of access to transplantation and recipient/donor outcomes, by reducing time to transplant and increasing the number of pre-emptive transplants. This would reduce time on dialysis, decreasing environmental and health impacts.

At the same time, the environmental impacts of the donor pathway itself can be addressed and minimised.

Project objectives

The Centre for Sustainable Healthcare (CSH) partnered with NHS Blood and Transplant (NHSBT) and the UK Kidney Association to secure Health Foundation support and funding for a three-month initial LKD project, which aimed to ensure the following:

- The living kidney donor assessment pathway is mapped
- Variations are understood
- Environmental impacts of the pathway are calculated
- Sources of inequity in the pathway are identified
- Findings are presented and collective community goals agreed

These essential preparatory steps allow for effective pathway redesign.

Methodology

Selection of sites

Three services were chosen with input from the UK Living Kidney Donation (UKLKD) Network to provide insight into pathway variations in different contexts (e.g. urban/rural, transplant/non-transplant centre). Representatives of the clinical teams and those with lived experience of the pathways explored/ analysed each pathway.

Carbon footprint analysis

A detailed appraisal of each unit of activity along the pathway, involving an in-depth analysis of all corresponding activities, events and products and then subsequent calculation of the associated carbon footprint using published carbon emission factors.

Data analysis for inequity hotspots

Analysis of the total number of donors, completion and drop-out rates, time on the pathway and demographic information of donors.

Lived experience interviews

Semi–structured interviews with lived experience representatives from the assessment centres.

Pathway mapping

- **Boundaries** – The living donor assessment pathway was defined as being from the initial contact with the potential donor (virtually or at donor centre) up to the pre-operative appointment before surgery.
- **Donor group** – All new admissions onto the potential donor caseload from January 2023- August 2024. Inclusions: directed donors. Exclusions: donors part of the shared scheme, non-directed altruistic donors

The pathways begin with initial donor contact and conclude at the pre-operative appointment. Potential donors can leave the pathway at any stage, the decision points highlight where it was identified they are most likely to exit. Bradford adjusted their pathway after initial exploration. Both the original and revised versions are shown to highlight changes and facilitate an analysis of the carbon impact resulting from these.

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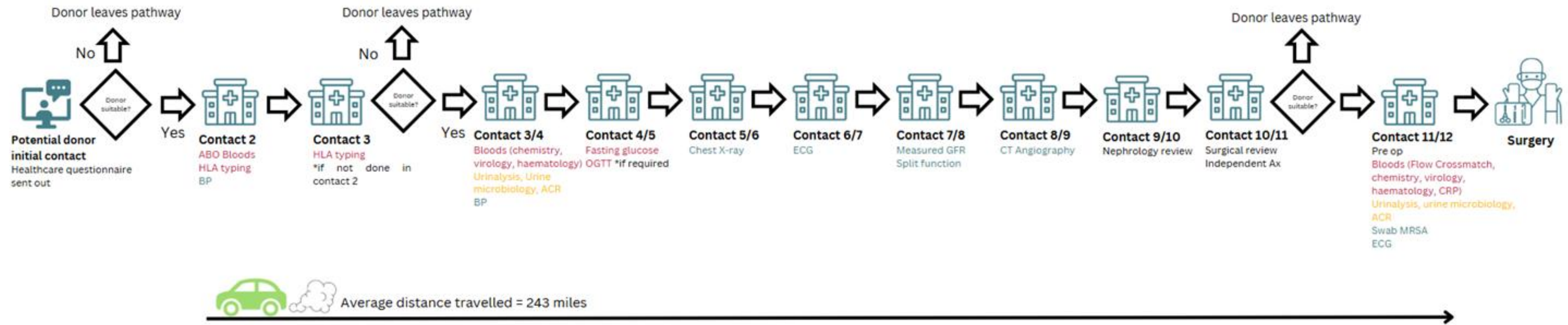
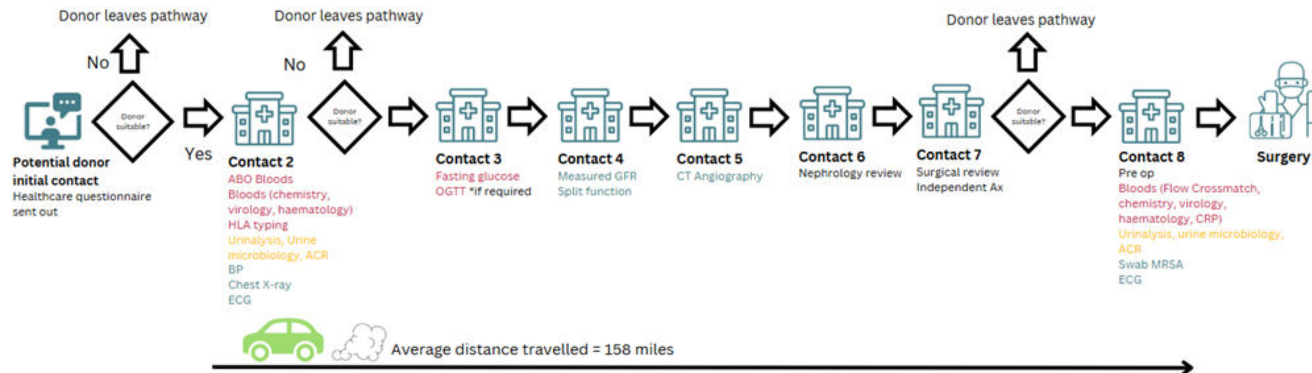
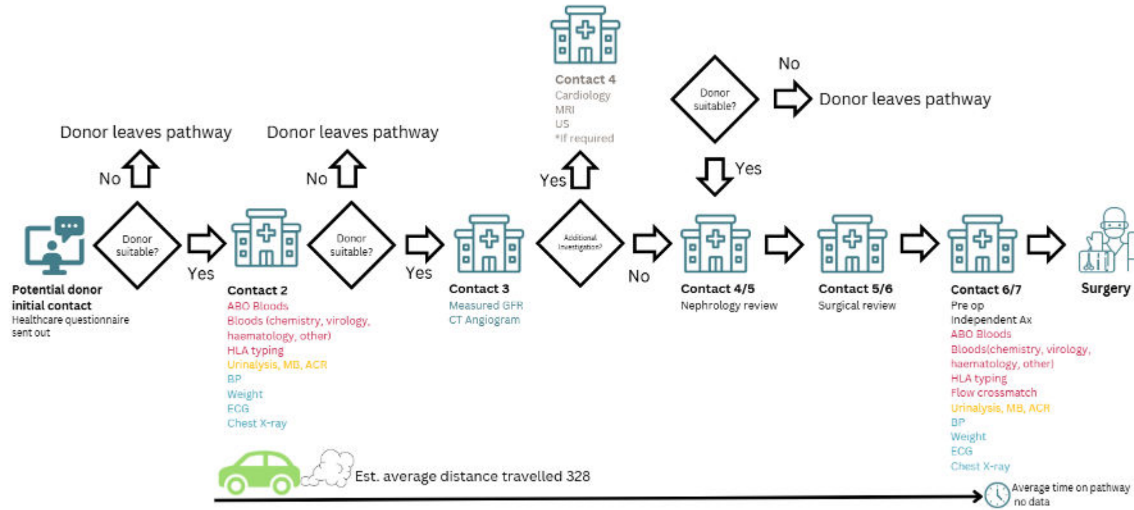
Bradford (previous pathway) Shared responsibility with transplant centre (Leeds).



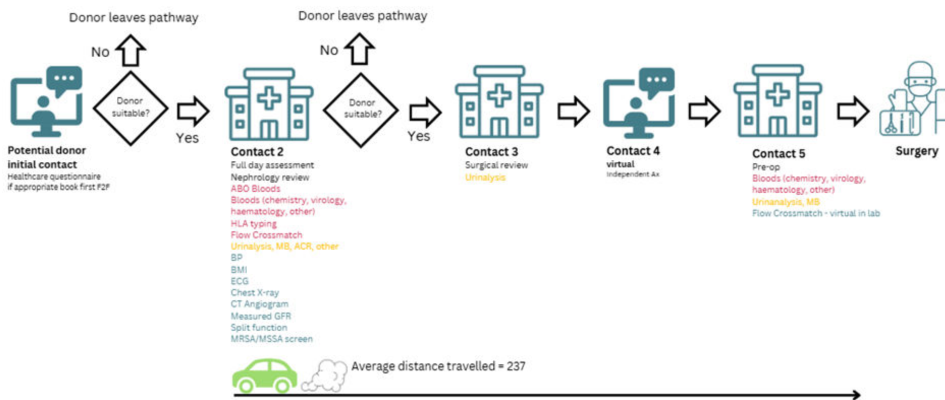
Bradford (new pathway)



Cardiff. Shared responsibility with non-transplant centre (Swansea).



Belfast. All assessments performed in transplant centre.



Carbon footprint analysis

Methodology

A hybrid approach was used to estimate the carbon footprint of the LKD assessment pathway at each of the three sites. Each site provided activity data representing a “typical” LKD assessment pathway, which was then converted into GHG emissions using primary data or emission factors derived from published studies and grey literature. For elements such as the virtual living donor consultation, overheads like energy and water, donor and staff travel, and most diagnostics and blood tests, a process-based analysis was conducted to calculate GHG emissions. For certain blood tests lacking published carbon footprint data, an Environmentally Extended Input-Output Analysis (EEIOA) was used. Table 1 details the activity data and a summary of the methodology and data sources used to calculate their carbon footprint. See full carbon report for a breakdown of the methodology.

Table 2: summary of methodology and data sources

Activity data	Methodology and data sources		
	Bradford	Cardiff	Belfast
Donor travel	Site-specific data based on a sample of 90 anonymised patient postcodes	No site-specific data. Carbon footprint estimated based on average post code distance in Mid and South Wales to sites.	Site-specific data based on a sample of 8 anonymised patient postcodes
Staff commuting	Sample of staff postcodes	No site-specific data. Carbon footprint estimated based on extrapolated data from the Wales national decarbonisation strategy.	Sample of living kidney coordinator and consultant nephrologist postcodes
Transportation of bloods to labs	Site-specific data based on distance of site to labs.	Site-specific data based on distance of site to labs.	Site-specific data based on distance of site to labs.
Electricity, gas and water overheads	Site specific energy consumption data taken from 2022/23 ERIC data[i]. DESNZ 2024 database[ii] used to convert energy data into GHG emissions.	Site specific 2023/24 energy consumption data provided by Morriston Hospital. No site-specific data provided for UHW, instead data extrapolated from Morriston Hospital. DESNZ 2024 database[ii] used to convert energy data into GHG emissions.	No site-specific data. Overheads estimated based on average energy consumption of Bradford and Cardiff.
Blood tests	Phlebotomy, vials, blood chemistry, & blood haematology tests: carbon footprints taken directly from Spoyalo et al, 2023[iii]. Blood virology, OGTT, fasting glucose, lipids, PSA, MRSA screening: carbon footprint data based on and extrapolated from Spoyalo et al, 2023[iii]. ABO blood group, HLA typing, flow cross match: Environmentally extended input output analysis undertaken (EEIOA).		
Diagnostics	Blood pressure, chest x-ray, ultrasound, CT angiography: data taken from McAlister et al, 2022[iv] and adjusted to UK context. Split function and measured GFR: estimated based on the carbon footprint of a CT scan from McAlister et al, 2022[iv]		
Urine tests	Urinanalysis and microbiology: carbon footprints taken from McAlister et al, 2021[v] and adjusted to UK setting.		

	Urine ACR: estimated based on energy consumption of spectrophotometer machine Cytology: carbon footprint extrapolated from McAlister et al, 2021[v].

Results

The average carbon footprint of a 'typical' LKD assessment pathway, across three sites (excluding Bradford's previous pathway), is estimated to be **114.2 kgCO2e per donor**. The largest greenhouse gas (GHG) emissions contributor is **donor travel**, accounting for 62% of the total, 71.0 kgCO2e. Blood and swab tests make up 17% (19.5 kgCO2e), while diagnostics contributes 10% (11.3 kgCO2e). Staff travel adds 7% (7.7 kgCO2e), and overhead energy consumption accounts for 3% (3.3 kgCO2e). Urine tests contribute 1% (1.4 kgCO2e) and transporting blood samples to external labs add a negligible 0.001% (0.0008 kgCO2e) **(Figure 1).**

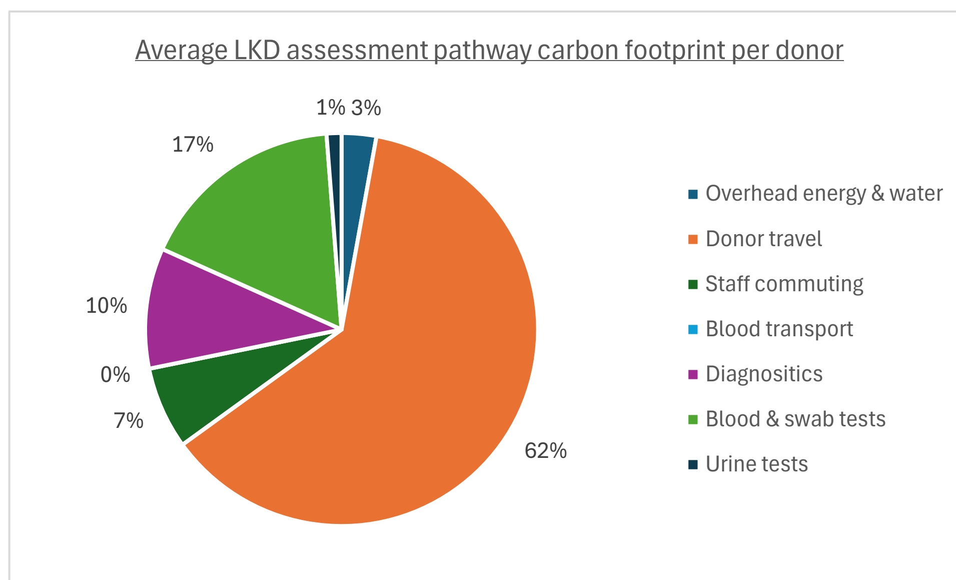


Figure 2: average LKD assessment pathway carbon footprint per donor

For each site, the carbon footprint of a 'typical' LKD assessment pathway is estimated to be:

- Bradford (previous pathway): **112.9 kgCO2e** per donor
- Bradford (new pathway): **92.3 kgCO2e** per donor
- Cardiff: **139.0 kgCO2e** per donor
- Belfast: **111.3 kgCO2e** per donor

Table 3 outlines the average carbon footprint of the LKD assessment pathway per donor, along with the carbon footprint per contact at each site. Excluding Bradford's previous pathway, Bradford's new LKD assessment pathway has the greatest number of contacts, 8, but results in the lowest overall carbon footprint per donor, at 92.3 kgCO2e. Cardiff, with 7 contacts, has the highest overall carbon footprint per donor at 139.0 kgCO2e. Belfast, despite having the fewest contacts, has an overall carbon footprint of 111.3 kgCO2e per donor.

Table 3: Comparison of a typical living kidney donor assessment pathway at each site

	GHG emissions per donor contact (kgCO2e)												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total (kgCO2e)**
Bradford (previous pathway)	0.05	10.5	10.3	7.4	6.9	6.5	6.3	15.6	9.4	6.3	11.5	22.2	112.9
Bradford (new pathway)	0.05	19.3	6.9	15.6	9.4	6.3	12.6	22.1					92.3
Cardiff	0.05	28.0	22.3	9.3	21.9	21.5	36.03						139.0
Belfast	0.19	60.4	23.5	0.3	26.9								111.3

As part of this project, Bradford revised their LKD assessment pathway. Both the previous and updated pathways were carbon footprinted and compared. In the new, streamlined pathway, the number of appointments was reduced from 12 to 8, lowering the estimated carbon footprint from 112.9 kgCO2e per donor to 92.3 kgCO2e per donor.

Discussion

GHG emissions from donor travel are a major contributor to the overall carbon footprint of the LKD assessment pathway and are a key factor driving differences in per donor carbon footprints across the three sites. In Bradford's new pathway, donors can attend their first four appointments at a local hospital, reducing travel-related emissions, as only the final four contacts require travel to a larger hospital. In contrast, the transplant centre in Belfast serves all of Northern Ireland, and the transplant centre in Cardiff serves the population of South and Mid Wales. In particular, even though there are fewer face-to-face contacts required in Belfast, the donor travel that is required is much further, impacting the average GHG emission estimates. Belfast's site at Belfast City Hospital's average GHG emissions per donor return journey was the highest of the sites, at 22.54 kgCO2e (the next highest was the University Hospital Wales for contacts 5, 6, & 7, at 20.72 kgCO2e).

Table 4: Average donor travel mileage per contact per site

Site	Hospital name	Average GHG emissions per donor return journey (kgCO2e)
Bradford	St Lukes	5.38
	Bradford Royal Infirmary	5.33
	St James University Hospital, Leeds	11.49
Belfast	Belfast City Hospital	22.54
Cardiff	Contacts 2, 3 and 4 (at either Morriston or UHW)	13.41
	University Hospital Wales (contacts 5, 6 & 7)	20.72

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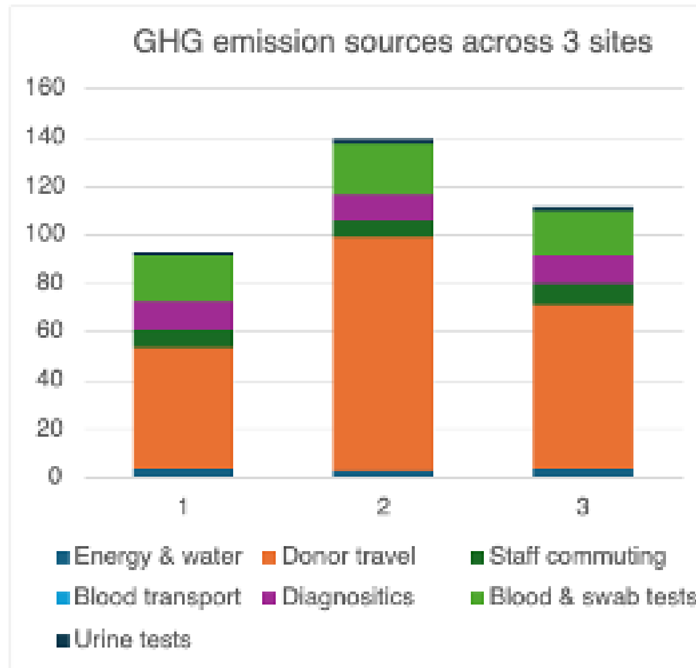

Figure 3: Greenhouse gas emissions across the three sites

Pathways with fewer face-to-face (F2F) appointments tend to have a lower carbon footprint compared to those with more contacts. For example, as part of their streamlining, Bradford reduced their carbon footprint by 20.6 kgCO2e per donor by consolidating blood, swab, urine tests, and diagnostics into a single appointment, rather than spreading them across multiple visits. Similarly, Belfast has streamlined their tests and diagnostics into a single full-day contact, resulting in a total of five contacts. When compared to Cardiff's pathway, Belfast has two fewer contacts and a carbon footprint that is 27.7 kgCO2e lower. Consolidating diagnostics and tests into fewer F2F contacts reduces GHG emissions associated with donor travel and overhead energy consumption.

GHG emissions related to diagnostic procedures—such as blood, swab, and urine tests—are relatively consistent across the three sites, indicating a low variation in the types of tests performed. At 21.2 kgCO2e per donor, Cardiff has the highest carbon footprint for diagnostics and tests, factored into by their increased number of repeat tests conducted during pre-operative visits as compared to the other two sites.

The carbon footprint of an average LKD assessment pathway is estimated to be **114.2 kgCO2e** per donor. This is excluding surgery. Comparing this to a haemodialysis annual carbon cost which is estimated to be **3 tCO2e** per patient per year, the LKD assessment pathway is small in comparison.

Reducing the carbon footprint of the LKD assessment pathway

1. Consolidate diagnostics and tests into fewer in-person visits. This minimizes the need for multiple trips and reduces GHG emissions from donor travel. This approach is only feasible if the hospital can conduct the required specialised tests. Also, 'one stop shops' are not always possible for

transplant centres as its often more expensive to have dedicated slots for the different diagnostics.
2. If consolidating the F2F contacts is not feasible, perform the more common blood tests at a local hospital or GP surgery. Again, this reduces donor travel to the larger hospitals.
3. Schedule more virtual appointments rather than F2F where possible. (Of note is that this approach may make donors feel less safe or secure, resulting in fewer donors. There needs to be a balance.)
4. Make sure there is a clear indication in the tests and diagnostics required.

Limitations

We were required to use assumptions and extrapolate data from other sites in some cases where there was a lack of comprehensive site-specific data for activity metrics. Additionally, variations existed in the datasets provided by each of the sites. Due to the short time scale of the project, it wasn't possible to estimate the carbon footprint of each diagnostic test for each site. Carbon footprints for these had to be estimated from published literature, requiring assumptions on the testing and consumables used.

Exploration of donor experience and equity hotspots

Donor lived experience summary

Individual experiences highlight personal perspectives rather than representing the views of people all people who have experienced the pathway or share protected characteristics. These experiences help us understand the experience of the pathway from the user perspective, highlighting any potential differences from staff, and to highlight any potential inequities.

Donor's experience

Both donors were motivated by a personal connection rather than a recruitment effort.

"I used to go with my brother to dialysis three times a week, and experiencing that with him made me want to help."

Both did their own research to understand process.

"I did it myself. There wasn't any outreach from the care team. I just asked at the hospital's renal unit, and they referred me to the transplant team."

"I didn't have much knowledge about kidney transplants before, so I had to do some research myself".

Both stated the relevant pathway map matched their experiences and both found the donation process straightforward

"I think they've been doing this for over 30 years, and they've refined the process. Everything was explained clearly, and any questions I had were already answered by the time I thought of them."

One interviewee emphasised the personal benefits of regular health check-ups post-donation.

“I get an annual check-up now, and everything’s fine. Without the donor process, I probably wouldn’t go to the hospital as regularly. That way, any small health issues get picked up early, which is a benefit."

One donor highlighted the importance of face-to-face consultations for making significant medical decisions and receiving detailed explanations.

"For something as serious as this, face-to-face contact is important. You could use virtual meetings for some parts, but in-person consultations are crucial, especially when it comes to the tests and making sure everything is properly explained."

One donor’s experience was 10–11 months from initial contact to surgery.

Impact on daily life:

Both donors felt the process had minimal disruption to the family’s routine and work.

“I was out of the hospital by Friday and back on my feet by Monday, so it didn’t disrupt things too much."

One donor was self-employed and worked around the process and one had good support from their employer for their leave and recovery. One donor lived close to the hospital so, travel time was minimal in terms of disruption and cost.

"I ran my own business, so taking time out wasn’t a big issue. Plus, I only lived about 10 minutes from the hospital. But I can see how it could be problematic for someone who had to travel further or had a stricter work schedule."

Recommendations for improvement:

Streamlining: Combining appointments and reducing the number of visits would make the process more efficient.

Outreach: Hospitals should consider initiating conversations with family members about donation to ease the burden on potential recipients.

"Reducing the burden on the patient to reach out to their loved ones about becoming a donor. If the hospital could initiate that conversation with the next of kin, it might make things easier."

Support Networks: Establishing support groups for donors (e.g., via WhatsApp or Facebook) could provide reassurance and a sense of community.

"Creating support groups—maybe WhatsApp or Facebook groups where people who’ve gone through the process can connect."

Reducing physical appointments by increasing online options could be beneficial for those with busy schedules or long travel distances.

"Reducing physical appointments by doing things online would be a huge improvement”

Potential for some digital elements, however, emphasis on the necessity of face-to-face interactions in such critical procedures.

Equity and education:

Cultural Barriers: Address misconceptions in specific communities, such as the belief in some Muslim communities that live organ donation is not allowed. Recommend partnering with community leaders to spread accurate information.

"The NHS should work with community leaders or mosques to spread the message that live donation is permissible. The message coming from within the community is much more effective than it coming from the NHS."

"It's about approaching it in the right way to reach the people who might not otherwise know."

Inequities in transplant access

A 2020 study by Pruthi et al. highlighted significant inequities in kidney transplant access across the UK, highlighting that factors such as socioeconomic status, ethnicity, age, and centre-specific practices influence recipient outcomes. Disadvantaged groups, particularly ethnic minorities and individuals from lower socioeconomic backgrounds, have reduced access to early (pre-emptive) transplant listings. Additionally, the study found that centre-specific factors, such as the number of consultants and the presence of a transplant centre, positively correlate with higher listing rates, while **rigid protocols may restrict access**. Pruthi et al. suggest that targeted interventions are essential to address these disparities and to promote equitable access to transplantation.

This project aimed to explore potential inequity hotspots of the kidney donor pathways at the three donor assessment sites through examining caseload data and engaging with key staff members**.** Our analysis is limited by the short time-frame of this project and the data that could be obtained by sites.

Caseload data analysis

Number entering the pathway

The data on the number of patients entering each pathway varies due to differences in data collection timeframes across sites, limiting direct comparisons.

Average time from first appointment to donation (for those who completed donation)

- **Bradford:** (Previous Pathway): Average 482.5 days
- **Cardiff**: Not obtainable.
- **Belfast:** Average 181 days

This data suggests that fewer visits and a more streamlined process may shorten the time required in the donation pathway, potentially improving recipients' quality of life by reducing the reliance on dialysis, improving the donor experience, and subsequently minimising the carbon impact associated with long-term kidney disease management.

Exists from the pathway

The number and reasons for potential donors exiting the pathway varied across the three sits:

- Anecdotally staff across all sites reported the initial health questionnaire the most significant dropout point.
- Data from one centre showed 62.5% of respondents to the healthcare questionnaire were found unsuitable or withdrew at some stage of the pathway.
- It was felt most exits from the pathway were due to medical reasons or a recipient receiving a deceased donation.

Pre-emptive listing

Data taken from the NHS Blood and Transplant (NHS BT) annual report (1 April 2023 – 31 March 2024) details similar pre-emptive listing rates for Bradford (31%) and Cardiff (33%) with higher rates for Belfast (47%) where donor assessments are integrated at the transplant centre.

Demographic comparison across sites

Demographic data varied in availability across the three sites, meaning comparison and analysis was not possible. But data available showed slight majority of male donors, with most being under 55 years of age.

LKD community workshop

As part of the project a workshop was held online with participants with a wide range of job roles within LKD services, wider services and those with lived experience.

Does our pathway analysis match your experiences of the current assessment process?

Participants felt the analysis accurately reflected their experiences, especially regarding travel distances for donors. Suggestions included consolidating appointments to streamline processes. “One-stop shops” should be considered since many donors are busy. Delays, such as those caused by interfacing with other departments like cardiology, frustrate donors. Donors are also concerned by risk of inflexible pathways, keen to use local testing options and choices for online consultations, aware of financially constrained donors, and interested in psychological evaluation for non-directed donors.

What causes the variations between the services?

Digressions from mapped pathways occurred due to mistakes in labelling of samples, missed transport of samples to the labs, inexperience of nurses, transplant nurses being unavailable for processing samples, and donors arriving late to appointments, disrupting the appointment logistics. Other inefficiencies include the resistance to adopting new practices, the “this is how we’ve always done it” mentality, funding decisions, the differences between rural and urban centres (with urban centres benefiting from reduced travel distances), specialised tests (such as measured GFR) not being conducted at local hospitals or GP practices, issues with digital systems at some local testing units, and concerns over radioactive materials.

What could be changed?

Focusing on the issue of donor travel: one-stop shops could be established, transplant centres should be strategically positioned within an area, more patient telephone interaction (as opposed to face-to-face) encouraged, consider mobile transplant teams, determine feasibility of virtual independent assessments, explore local immunology options, and investigate alternatives to requiring donor visits for final cross-match. On the issue of systems and communication, IT systems must be able to interoperate. Other logistical issues could be improved such as those surrounding sample transport efficiency, quicker pathways for specialty referrals, and addressing challenges surrounding primary

care facilities. Considerations for donor engagement, such as those who prefer face-to-face interactions, those from non-English speaking communities, those with financial constraints, must be kept, and collaboration between recipient and donor teams should remain a focus to increase donor pathway completion. Hospital executives should be engaged in the process to encourage focused funding, resources, and staffing.

Who should lead future improvement work?

Changes must occur at all three levels: local, regional, and national. Changes need to be made at the department level, and regional networks should be established, while best practices are promoted nationally. Trusts require central oversight from bodies like NHS England for governance. Financial resources need to flow to local leaders and teams, who also should be equipped with practical tools and funding pathways to drive changes within trusts. Peer exchanges with other transplant services can provide insights and NHSBT's best practice guidelines can standardize protocols. Living kidney donor coordinators are positioned to lead change but need direction from senior leadership and policymakers for a cohesive framework. Currently, responsibilities are fragments across devolved nations and hospitals.

How could changes be implemented

Budget holders need to buy-in to the pathway. While dialysis is funded more generously due to its life-saving impact, kidney donations are also critical. Cultural change should be promoted; many are hesitant to donate kidneys, preferring deceased donor options, so living donations need to be encouraged. Donor pool awareness should be expanded and barriers addressed. Potential donors should have options in appointment types, and should be able to provide feedback via survey should they need proceed with the donation. Also, potential donors should be aware of potential time delays. Incentives, financial or otherwise, could be proposed for pathway improvements, while stakeholder collaboration should be fostered at all points along the donation pathway. Addressing the resistance to change and problems in funding are key barriers to implementing systems change.

What learning could be shared with other pathways?

Lessons on identifying unnecessary diagnostics, unwarranted variation, and centralising specialist procurement for all pathways could be shared amongst others. Exploring options for psychological support and looking into international practices were also considerations. It was also noted that politicisation of NHS is a problem and that positive variation and negative variation are important to separate out.

Summary

Pathway mapping highlights significant differences across sites in:

- The number of contacts in which investigations take place.
- Locations and distances travelled by patients.
- Use of online consultations.
- Average duration of the pathway

Dropout rates - All sites reported high dropout rates during the initial health screening, and fewer numbers at later stages due to valid medical reasons. Non-medical withdrawals were rare, indicating effective screening at the beginning of the process minimising wasted resources.

Donor lived experience and equity - Feedback from donors showed they were highly self-motivated, health-educated, and had supportive work environments. Donors lived near centres or had the ability

to travel independently and easily to appointments. Consideration is needed for those without similar advantages. Full demographic data from all sites was unavailable within the timeframe of the project.

Next steps

Variations across pathways suggest potential for streamlining processes and improving data consistency. Changes could reduce the carbon footprint of the assessment pathway, however, in light of the small carbon costs of the pathway compared to dialysis, priority should be on increasing pathway flexibility and providing support for potential donors to enhance access and equity.

Section 3: detailed reporting

Appendix A: carbon report

Methodology

The carbon footprint of the living kidney donor assessment pathway at each site has been estimated using a hybrid methodology. Table 1 details the activity data and a summary of the methodology and data sources used to calculate their carbon footprint. See Appendix 1 for a detailed breakdown of the methodology and assumptions.

Table 5: Summary of methodology and data sources

Activity data	Methodology and data sources		
	Bradford	Cardiff	Belfast
Donor travel	Site-specific data based on a sample of 90 anonymised patient postcodes	No site-specific data. Carbon footprint estimated based on average post code distance in Mid and South Wales to sites.	Site-specific data based on a sample of 8 anonymised patient postcodes
Staff commuting	Sample of staff postcodes	No site-specific data. Carbon footprint estimated based on extrapolated data from the Wales national decarbonisation strategy.	Sample of living kidney coordinator and consultant nephrologist postcodes
Transportation of bloods to labs	Site-specific data based on distance of site to labs.	Site-specific data based on distance of site to labs.	Site-specific data based on distance of site to labs.
Electricity, gas and water overheads	Site specific energy consumption data taken from 2022/23 ERIC data[vi]. DESNZ 2024 database[vii] used to convert energy data into GHG emissions.	Site specific 2023/24 energy consumption data provided by Morriston Hospital. No site-specific data provided for UHW, instead data extrapolated from Morriston Hospital. DESNZ 2024 database[ii] used to convert energy data into GHG emissions.	No site-specific data. Overheads estimated based on average energy consumption of Bradford and Cardiff.
Blood tests	Phlebotomy, vials, blood chemistry, & blood haematology tests: carbon footprints taken directly from Spoyalo et al, 2023[viii].		

	Blood virology, OGTT, fasting glucose, lipids, PSA, MRSA screening: carbon footprint data based on and extrapolated from Spoyalo et al, 2023[iii]. ABO blood group, HLA typing, flow cross match: Environmentally extended input output analysis undertaken (EEIOA).
Diagnostics	Blood pressure, chest x-ray, ultrasound, CT angiography: data taken from McAlister et al, 2022[ix] and adjusted to UK context. Split function and measured GFR: estimated based on the carbon footprint of a CT scan from McAlister et al, 2022[iv]
Urine tests	Urinanalysis and microbiology: carbon footprints taken from McAlister et al, 2021[x] and adjusted to UK setting. Urine ACR: estimated based on energy consumption of spectrophotometer machine Cytology: carbon footprint extrapolated from McAlister et al, 2021[v].

Results

Average carbon footprint of a LKD assessment pathway

The average carbon footprint of a 'typical' LKD assessment pathway, across three sites (excluding Bradford's previous pathway), is estimated to be 114.2 kgCO2e per donor. The largest greenhouse gas (GHG) emissions contributor is donor travel, accounting for 62% of the total, 71.0 kgCO2e. Blood and swab tests make up 17% (19.5 kgCO2e), while diagnostics contributes 10% (11.3 kgCO2e). Staff travel adds 7% (7.7 kgCO2e), and overhead energy consumption accounts for 3% (3.3 kgCO2e). Urine tests contribute 1% (1.4 kgCO2e) and transporting blood samples to external labs add a negligible 0.001% (0.0008 kgCO2e) (Figure 1).

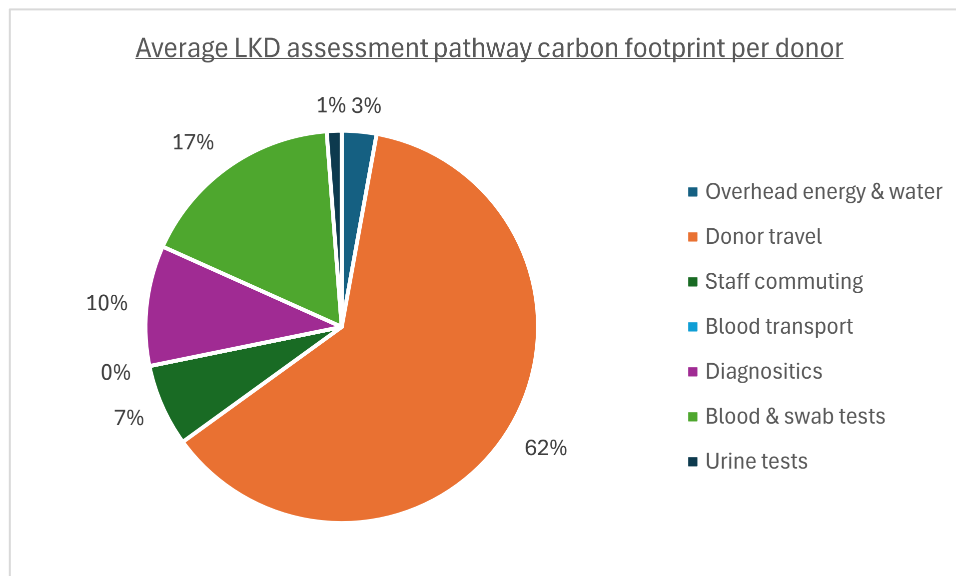

Figure 4: average LKD assessment pathway carbon footprint per donor

Table 6: breakdown of the carbon footprint of an average LKD assessment pathway

Activity data	Total (kgCO2e)	Contribution
Donor travel	71.0	62
Blood & swab tests	19.5	17
Diagnostics	11.3	10
Staff commuting	7.7	7
Overhead energy & water	3.3	3
Urine tests	1.4	1
Transportation of blood & swab tests	0.0008	0.001
Total	**114.2**	

Site comparisons

For each site, the carbon footprint of a 'typical' LKD assessment pathway is estimated to be:

- Bradford (previous pathway): 112.9 kgCO2e per donor
- Bradford (new pathway): 92.3 kgCO2e per donor
- Cardiff: 139.0 kgCO2e per donor
- Belfast: 111.3 kgCO2e per donor

Table 3 outlines the average carbon footprint of the LKD assessment pathway per donor, along with the carbon footprint per contact at each site. Excluding Bradford's previous pathway, Bradford's new LKD assessment pathway has the greatest number of contacts, 8, but results in the lowest overall carbon footprint per donor, at 92.3 kgCO2e. Cardiff, with 7 contacts, has the highest overall carbon footprint per donor at 139.0 kgCO2e. Belfast, despite having the fewest contacts, has an overall carbon footprint of 111.3 kgCO2e per donor.

Table 7: Comparison of a typical living kidney donor assessment pathway at each site

	GHG emissions per donor contact (kgCO2e)												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total (kgCO2e)**
Bradford (previous pathway)	0.05	10.5	10.3	7.4	6.9	6.5	6.3	15.6	9.4	6.3	11.5	22.2	112.9
Bradford (new pathway)	0.05	19.3	6.9	15.6	9.4	6.3	12.6	22.1					92.3
Cardiff	0.05	28.0	22.3	9.3	21.9	21.5	36.03						139.0
Belfast	0.19	60.4	23.5	0.3	26.9								111.3

Bradford

Bradford recently revised their LKD assessment pathway, and as part of this project, both the previous and updated pathways were carbon footprinted and compared. The original pathway involved 12 contacts and had an estimated carbon footprint of 112.9 kgCO2e per donor. In the new, streamlined

pathway, the number of appointments was reduced to 8, lowering the estimated carbon footprint to 92.3 kgCO2e per donor. This change resulted in a carbon saving of 20.6 kgCO2e per donor. Much of this reduction can be attributed to decreased donor travel due to fewer contacts required.

Looking at Bradford's new LKD assessment pathway, donor travel accounts for 54% of the total carbon footprint per donor, 49.7 kgCO2e. Blood and swab tests contribute, 18.9 kgCO2e (21%), diagnostics 11.8 kgCO2e (13%), staff travel 7.4 kgCO2e (8%), and overhead energy 3.5 kgCO2e (4%). Urine tests add 1.0 kgCO2e (1%) and transporting blood samples to external labs add 0.001 kgCO2e (0.001%) (Figure 2).

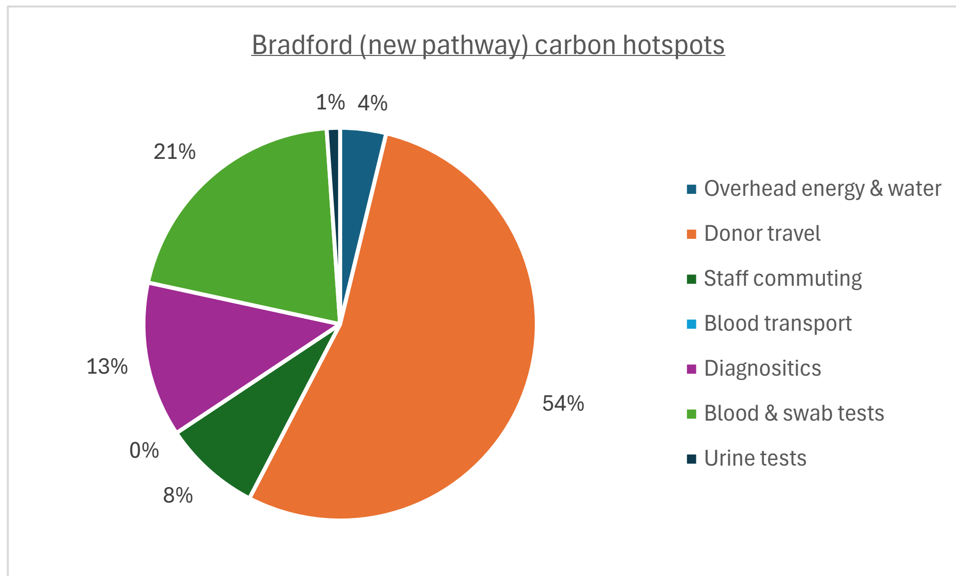

Figure 5: Bradford (new pathway) LKD assessment pathway carbon hotspots per donor

Cardiff

A typical LKD assessment pathway at Cardiff has 7 contacts and an estimated carbon footprint of 139 kgCO2e per donor. From Figure 3, donor travel accounts for 69% of Cardiff's assessment pathway per donor, 95.7 kgCO2e. Blood and swab tests contribute, 21.2 kgCO2e (15%), diagnostics 11 kgCO2e (8%), staff travel 6.7 kgCO2e (5%), and overhead energy 3.0 kgCO2e (2%). Urine tests add 1.5 kgCO2e (1%) and transporting blood samples to external labs add 0.001 kgCO2e (0.001%).

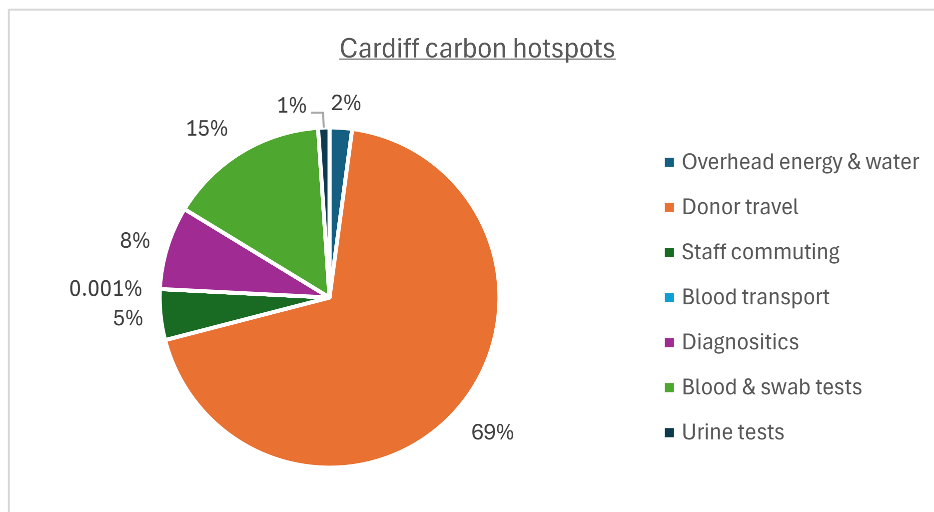

Figure 6: Cardiff LKD assessment pathway carbon hotspots per donor

Belfast

A typical LKD assessment pathway at Belfast has 5 contacts and an estimated carbon footprint of 111.3 kgCO2e per donor. From Figure 4, donor travel accounts for 61% of Belfast's assessment pathway per donor, 67.6 kgCO2e. Blood and swab tests contribute, 18.4 kgCO2e (17%), diagnostics 11.2 kgCO2e (10%), staff travel 9.1 kgCO2e (8%), and overhead energy 3.3 kgCO2e (3%). Urine tests add 1.7 kgCO2e (2%) and transporting blood samples to external labs add 0.0001 kgCO2e (0.0001%).

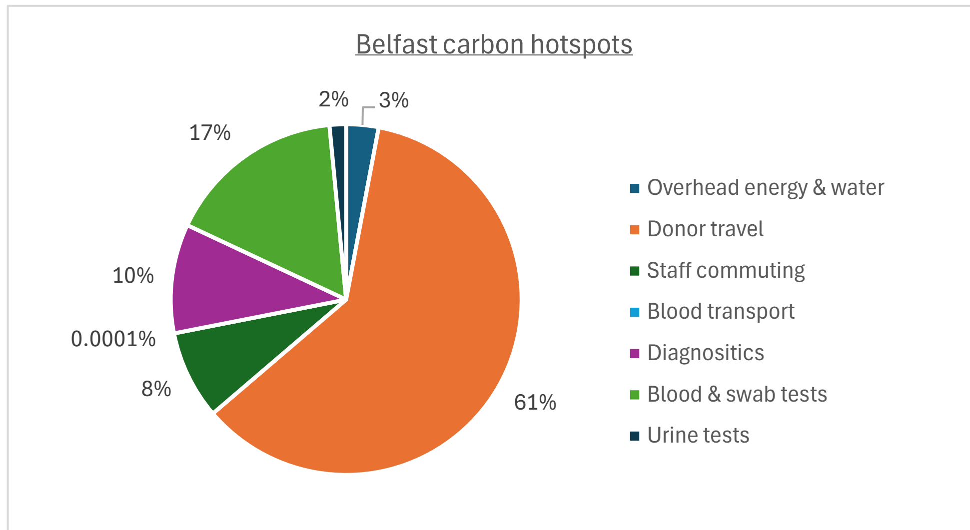

Figure 7: Belfast LKD assessment pathway carbon hotspots per donor

Discussion

Donor travel

GHG emissions from donor travel are a major contributor to the overall carbon footprint of the LKD assessment pathway and are a key factor driving differences in per donor carbon footprints across the three sites GHG emissions related to donor travel in Bradford are around half of the GHG emissions of Cardiff's donor travel. The population of Bradford is served by the regional transplant centre in Leeds, a smaller population size compared to the other two sites. In Bradford's new pathway, donors can attend their first four appointments at a local hospital, reducing travel-related emissions, as only the final four contacts require travel to a larger hospital. In contrast, the transplant centre in Belfast serves all of Northern Ireland. While they have just three face-to-face contacts, all are at Belfast City Hospital, meaning donors often travel much further despite the fewer appointments. Similarly, the transplant centre in Cardiff serves the population of South and Mid Wales. For contacts 2,3 and 4, donors are able to choose between Morriston Hospital (Swansea) and University Hospital of Wales (UHW) (Cardiff) to attend these contacts. However, for contacts 5, 6 and 7, all donors are required to attend UHW. Table 4 details the average miles travelled per donor at each site.

Table 8: average donor travel mileage per contact per site

Site	Hospital name	Average GHG emissions per donor return journey (kgCO2e)
Bradford	St Lukes	5.38
	Bradford Royal Infirmary	5.33
	St James University Hospital, Leeds	11.49
Belfast	Belfast City Hospital	22.54
Cardiff	Contacts 2, 3 and 4 (at either Morriston or UHW)	13.41
	University Hospital Wales (contacts 5, 6 & 7)	20.72

Number of Face-to-face contacts per pathway

The number of face-to-face (F2F) contacts also influences the variation in the carbon footprint of the LKD assessment pathway across the three sites. Pathways with fewer appointments tend to have a lower carbon footprint compared to those with more contacts. For example, Bradford reduced their carbon footprint by 20.6 kgCO2e per donor by consolidating blood, swab, urine tests, and diagnostics into a single appointment, rather than spreading them across multiple visits. Similarly, Belfast has streamlined their tests and diagnostics into a single full-day contact, resulting in a total of five contacts. When compared to Cardiff's pathway, Belfast has two fewer contacts and a carbon footprint that is 27.7 kgCO2e lower. Consolidating diagnostics and tests into fewer F2F contacts reduces GHG emissions associated with donor travel and overhead energy consumption.

Variation in blood, swab, urine and diagnostic tests

GHG emissions related to diagnostic procedures—such as blood, swab, and urine tests—are relatively consistent across the three sites, indicating a low variation in the types of tests performed. Cardiff has the highest carbon footprint for diagnostics and tests, generating 21.2 kgCO_2e per donor, while Bradford (new) and Belfast report similar emissions levels at 18.9 kgCO_2e and 18.4 kgCO2e per donor. One contributing factor to Cardiff's higher emissions is the increased number of repeat tests and diagnostics conducted during pre-operative visits, which is notably higher than at the other two sites.

Average carbon footprint per LKD pathway

The carbon footprint of an average LKD assessment pathway is estimated to be 114.2 kgCO2e per donor. This is excluding surgery. Comparing this to a haemodialysis sessions which is estimated to be 3 tCO2e per patient per year, the LKD assessment pathway is small in comparison.

Reducing the carbon footprint of the LKD assessment pathway

- Since GHG emissions from donor travel are a significant contributor to the carbon footprint of the Living Kidney Donor (LKD) assessment pathway, consolidating diagnostics and tests into fewer in-person visits could help reduce emissions. For example, Belfast has streamlined their process by scheduling all necessary diagnostics and tests within a single day, minimizing the need for multiple trips. This approach, however, is feasible only if the hospital can conduct the required specialised tests. In Bradford, for instance, donors must travel to a larger hospital to undergo specific diagnostics like measured GFR and CT angiography, as these specialised tests are not available at the local hospital. However, it is recognised that one stop shops are

not always possible for transplant centres as its often more expensive to have dedicated slots for the different diagnostics.

- If its not feasible to consolidate F2F contacts, sites could look at whether the more common/general blood tests could be performed at a local hospital or GP surgery to reduce travel to the larger hospitals. For example, Bradford perform a lot of the blood and urine tests at a local hospital, closer to the donors home so less travel emissions are generated, and only
- More virtual appointments rather than F2F where possible, however, creating a less flexible pathway might result in fewer donors. For example, reducing the number of F2F visits might make donors feel less safe or secure. Needs to be balanced.
- Clear indication in the tests and diagnostics required – some sites undertaking kidney ultrasounds and PSA bloods but other sites aren't.

Limitations

A limitation of this study is the lack of comprehensive site-specific data for all activity metrics, which required us to use assumptions and extrapolate data from other sites in some cases to estimate carbon footprints. Additionally, among the sites where we obtained specific data, variations existed in the data sets provided. For instance, for donor travel, Bradford supplied a sample of 90 donor postcodes, whereas Belfast provided only 8.

Another limitation is that due to the short-time scale of the project, it wasn't possible to estimate the carbon footprint of each diagnostic, blood and urine test at each site. Instead, carbon footprints for the various tests were taken from published literature, where it was assumed, the tests would have been undertaken in the same way with the same consumables.

Detailed methodology

A hybrid approach was used to estimate the carbon footprint of the living kidney donor (LKD) assessment pathway at each of the three sites. For elements such as the virtual living donor consultation, overheads like energy and water, donor and staff travel, and most diagnostics and blood tests, a process-based analysis was conducted to calculate GHG emissions. Each site provided activity data representing a "typical" LKD assessment pathway, which was then converted into GHG emissions using emission factors derived from published studies and grey literature. For certain blood tests lacking published carbon footprint data, an Environmentally Extended Input-Output Analysis (EEIOA) was used. The following details the methodology, assumptions around activity data, and the carbon conversion factors applied. Table 1 details the activity data and a summary of the methodology and data sources used to calculate their carbon footprint.

Virtual living donor consultation

The carbon footprint of an outpatient telephone consultation, taken from the Greener NHS database, was used to estimate the GHG emissions of the virtual living donor telephone consultation (VLDC) at each site, where the initial donor contact is conducted virtually. The emission factor from Greener NHS was adjusted based on the average appointment duration at each location: 15 minutes at both Bradford and Cardiff, and 60 minutes at Belfast. For Belfast, the fourth contact on the pathway is also a virtual contact, a virtual independent assessment lasting 90 minutes.

Consultation and scan room overhead energy and water

Bradford

Face-to-face appointments take place at three hospitals in the area - St Lukes, Bradford Royal Infirmary, and St James University Hospital in Leeds. 2022/23 electricity, gas and water consumption, along with total occupied floor area for each of the sites was taken from the Estates Returns Information Collection (ERIC). Activity data was converted into GHG emissions using factors from the 2024 UK Government conversion factors for company reporting of greenhouse gas emissions (DESNZ) database. Assuming each site operates 365 days per year with 12 core operational hours a day, GHG emissions per square metres (m2) per minute was estimated for electricity, gas and water. Taken from a previous CSH project, it was assumed that the clinic rooms at each site measured 11.25 m2 and the scan rooms measured 22.5 m2.

Cardiff

Face-to-face appointments take place at two hospitals – Morriston Hospital (Swansea) and University Hospital of Wales (Cardiff). 2023/24 electricity, gas and water consumption per m2 was provided for Morriston Hospital by the Energy and Carbon Technical Services Officer. Assuming each site operates 365 days per year with 8 core operational hours a day, GHG emissions per m2 per minute was estimated for electricity, gas and water. Taken from a previous CSH project, it was assumed that the clinic rooms at each site measured 11.25 m2 and the scan rooms measured 22.5 m2. No site level data was provided for University Hospital of Wales, it was therefore assumed that the site had the same electricity, gas and water consumption per m2 as Morriston Hospital.

Belfast

Face-to-face appointments take place at Belfast City Hospital. No site level energy and water data was provided for Belfast City Hospital, therefore average energy and water consumption across Cardiff and Bradford was therefore used as an approximation for electricity, gas and water consumption at Belfast City Hospital.

Donor travel

Bradford

A sample of 90 anonymised donor postcodes was provided. For each of the three hospitals (St Lukes, Bradford Royal Infirmary, and St James University Hospital in Leeds), distance between the postcodes and site was estimated with the help of Free Map Tools and input into CSH's avoided patient travel calculator. The calculator estimated the mode of transport based on distance using the UK National Travel Survey and used conversion factors taken from the 2024 DESNZ database to convert mode and distance into GHG emissions. For each Hospital, GHG emissions for an average donor return journey was estimated.

Belfast

A sample of 8 anonymised donor postcodes was provided. Distance between the postcodes and Belfast City Hospital was estimated with the help of Free Map Tools and input into CSH's avoided patient travel calculator. The calculator estimated the mode of transport based on distance using the UK National Travel Survey and used conversion factors taken from the 2024 DESNZ database to convert mode and distance into GHG emissions. From this, GHG emissions for an average donor return journey was estimated.

Cardiff

No site-specific data was available for Cardiff. Instead, average travel distance was estimated based on the proportion of the population size and distance from Swansea Morriston Hospital and University Hospital of Wales (UHW), Cardiff. Population size of the 16 local authorities in Mid and South Wales based on 2023 data was taken from StatsWales. Contacts 2, 3 and 4 can be undertaken at either Swansea Morriston Hospital or (UHW), for these appointments, it was assumed that donors who lived closer to Swansea would travel to Morriston Hospital and donors who lived closer to Cardiff would travel to UHW. The distance from the mid-point of each local authority to either Morriston Hospital or UHW was estimated using Google Maps. To calculate the average distance travelled to the appointments which can take place at either hospital, the distance travelled was weighted according to the ratio of population size in the local authorities of the Swansea and Cardiff area. Based on population size, it was assumed that 37% of the population would attend these contacts at Morriston and 63% of the population would attend these contacts at UHW.

Contacts 5, 6 and 7 are undertaken at UHW only, serving all potential donors in South Wales. The distance from the mid-point of each local authority to UHW was estimated using Google Maps and weighted against the proportion of each local authority's population compared to the total population of the 16 local authorities in South and Mid Wales.

An average distance per donor was estimated and converted into GHG emissions using CSH's avoided patient travel calculator, and factors taken from the 2024 DESNZ database.

Site	Hospital name	Average GHG emissions per donor return journey (kgCO2e)
Bradford	St Lukes	5.38
	Bradford Royal Infirmary	5.33
	St James University Hospital, Leeds	11.49
Belfast	Belfast City Hospital	22.54
Cardiff	Contacts 2, 3 and 4 (at either Morriston or UHW)	13.41
	University Hospital Wales (contacts 5, 6 & 7)	20.72

Staff commuting

Bradford

An average return distance for staff was provided by Bradford and input into CSH's avoided patient travel calculator. The calculator estimated the mode of transport based on distance using the UK National Travel Survey and used conversion factors taken from the 2024 DESNZ database to convert mode and distance into GHG emissions. From this, GHG emissions for an average staff return journey per day was estimated. Commuting GHG emissions were apportioned per contact based on the number of patients staff would see per day at each contact.

Cardiff

2018/19 GHG emissions associated with NHS Wales staff's commuting and total staff numbers were taken from the NHS Wales Decarbonisation Strategy. Based on this data, and the assumption of 222 working days, an average carbon footprint per return journey for staff commuting was estimated. Commuting GHG emissions were apportioned per contact based on the number of patients staff would see per day at each contact.

Belfast

A sample of LKD coordinators and consultant nephrologist postcodes were provided. Distance between the postcodes and Belfast City Hospital was estimated with the help of Free Map Tools and input into CSH's avoided patient travel calculator. The calculator estimated the mode of transport based on distance using the UK National Travel Survey and used conversion factors taken from the 2024 DESNZ database to convert mode and distance into GHG emissions. From this, GHG emissions for an average staff return journey per day was estimated. Commuting GHG emissions were apportioned per contact based on the number of patients staff would see per day at each contact.

Site	Staff member	Average GHG emissions per staff return journey (kgCO2e)
Bradford	All staff	4.98
Cardiff	All staff	6.3
Belfast	LKD coordinator	17.46
	Consultant Nephrologist	2.74

Blood tests

GHG emissions factor associated with phlebotomy have been taken from a Canadian study by Spoyalo et al, 2023. This factor includes the following consumables: needle, latex free tourniquet, vacutainer, sterile wipes, gauze, micropore tape, plastic bag, gloves and laboratory requisition paper.

GHG emissions associated with blood chemistry, and blood haematology/clotting tests have been taken from the same study by Spoyalo et al, 2023. Due to data unavailability, emission factors have not been adjusted to reflect the UK electricity grid. For blood chemistry and blood haematology, emission factors include the vial type (green and blue), electricity and consumables used to perform test, and electricity used for pneumatic transport system for blood sample to be transported within the hospital from the consultation room to the lab.

GHG emissions associated with ABO blood group, HLA typing and flow cross match were estimated using a hybrid approach. An average emission factor for a blood vial was taken from Spoyalo et al 2023. For the flow cross match, 2 blood vials were required. Emissions associated with test processing were based on cost of processing. A cost of £14.39 per test processing was assumed for all three tests, this was taken from a previous CSH Green Surgery Challenge project. Cost was adjusted to account for inflation and converted into carbon using the SIC factor for 'human health services', taken from the 2021 UK Government SIC database.

For blood virology, it was assumed that the GHG emissions associated with processing one virus test would be the same as a 'total protein' test taken from Spoyalo et al, 2023. Based on the 2018 LKFT guidelines, it was assumed that 10 common viruses are tested for. For the blood vial, an average emission factor for a blood vial was taken from Spoyalo et al 2023

For other blood lipid tests and PSA blood test, one blood vial was included as well as the emission factor for an average processing of a blood test, both taken from Spoyalo et al, 2023.

Some donors are required to have either an Oral Glucose Tolerance Test (OGTT) or a fasting glucose test. During an OGTT, a blood sample is taken first. The donor then drinks a sweet drink and another blood sample is taken 2 hours after the drink is consumed. For emissions associated with an OGTT test, 2 phlebotomies and 2 blood vials were included, taken from Spoyalo et al, 2023. For the sweet drink, it was assumed that the donor would be given Rapilose, cost per drink was taken from the BNF and converted into carbon using the emission factor for pharmaceuticals taken from the 2021 UK Government SIC code database. For the fasting glucose test, one phlebotomy and one blood vial was included. For Bradford it was assumed that all donors undergo either a fasting glucose or OGTT and it was therefore assumed that 2/3rds of donors have a fasting glucose test and 1/3rd have an OGTT. For Cardiff, it was assumed that 50% of donors undergo either a fasting glucose or OGTT, 2/3rds of these donors who require either test have a fasting glucose test and 1/3rd have an OGTT.

GHG emissions associated with an MRSA screening were estimated using a bottom-up approach. The swab and container were based on materials and weights, the emissions associated with the incubator was based on a 400W machine with an incubation of 16 hours.

Diagnostic tests

GHG emission associated with a chest x-ray (CXR), ultrasound, and CT angiography have been taken from McAlister et al, 2022 and are based on the use of electricity and consumables for the diagnostics. It was assumed that the emissions associated with a generic ultrasound would be similar to that of a kidney ultrasound. As the study was based in Australia, electricity emission factors have been adjusted using the 2024 UK electricity grid emission factors taken from the 2024 DESNZ database. Consumables for the CXR include 2 gloves, an alcohol wipe, cotton sheet and cotton pillowcase (which get laundered). Kidney ultra sound consumables include 2 gloves, gel (14% propylene gycol) and tissue paper. It was assumed that the consumables used for a CT scan would be the same for a CT angiography and include, 4 pairs of gloves, alcohol wipe, slide sheet, cotton sheet, cotton pillowcase, 10ml syringe, 23G needle, alcohol wipe and contrast (270 mg/kg, 75 kg patient).

For the ECG, GHG emissions associated with a Clinell wipe and 10 disposable Ambu electrodes have been included. The ECG electrodes were estimated using a bottom-up process based approach including raw materials, packaging and transport. Weights were provided by CSH's KitNewCare project and the materials taken from Ambu's technical sheet and converted into GHG emissions using factors taken from the 2024 DESNZ database.

GHG emissions associated with blood pressure reading have been taken from Sanchez et al, 2020 and include a reusable cuff (lasting for 3 years, and used 20 times per day), a quarter of an alcohol wipe, and a disinfection in an enzyme bath every 5 days. Measured GFR and split function were not able to be assessed during the project period.

Urine tests

GHG emission associated with urinalysis and microbiology have been taken from McAlister et al, 2021and includes swabs, sample jar, test electricity, consumables, CO_2 and compressed air. As this study was based in Australia, electricity emission factors have been adjusted using the 2024 UK electricity grid emission factors taken from the 2024 DESNZ database.

For a urine ACR test, the energy use of a spectophotometre was included. It was assumed that the energy use of the machine would be the same as the machines used in Spoyalo et al, 2023. It was also assumed that the machine would be used for 3.67 minutes. Energy consumption per tests was converted into carbon using the 2024 DESNZ database.

Transportation of blood to labs

Bradford

All tests are processed onsite except the HLA typing which is processed at St James University Hospital (Leeds). A distance of 58 km between St Lukes Hospital and St James University Hospital was assumed, taken from Google Maps. Weights for vial were taken from Spoyala et al. 2023. It was assumed that the weight of the plastic bag for transportation of the blood sample is the same as the weight of a small fridge pharmacy bag as recorded during the Gloucestershire Green Team Competition 2022 and that the blood samples were transported in a small diesel van. Distance and weights were converted into carbon using the tonne.km emission factor for a small diesel van (including well-to-tank emissions) taken from the 2024 DESNZ database.

Cardiff

All tests are processed onsite except the cross flow match which is processed externally by Welsh Blood Services (located in Velindre NHS Trust). A distance of 9 km between UHW and Velindre NHS Trust was assumed, taken from Google Maps. Weights for vial were taken from Spoyala et al. 2023. It was assumed that the weight of the plastic bag for transportation of the blood sample is the same as the weight of a small fridge pharmacy bag as recorded during the Gloucestershire Green Team Competition 2022 and that the blood samples were transported in a small diesel van. Distance and weights were converted into carbon using the tonne.km emission factor for a small diesel van (including well-to-tank emissions) taken from the 2024 DESNZ database.

Belfast

All tests are processed onsite except virology and MRSA/MSSA screening which are sent to Royal Victoria Hospital. A distance of 4.5 km was assumed between Belfast City Hospital and Royal Victoria Hospital, taken from Google Maps. Weights for vial were taken from Spoyala et al. 2023. It was assumed that the weight of the plastic bag for transportation of the blood sample is the same as the weight of a small fridge pharmacy bag as recorded during the Gloucestershire Green Team Competition 2022 and that the blood samples were transported in a small diesel van. Distance and weights were converted into carbon using the tonne.km emission factor for a small diesel van (including well-to-tank emissions) taken from the 2024 DESNZ database.

Appendix B: workshop full summary

Does our pathway analysis match your experiences of the current assessment process?

Participants felt the analysis accurately reflected their experiences, especially regarding travel distances for donors. Suggestions included consolidating CT, mGFR, and Nephrology appointments into one visit. One centre conducted ultrasounds, which could be eliminated. Independent assessments could occur the same day as pre-op, but caution is warranted due to potential psychological impacts.

While "one-stop shops" are often impractical for transfer or transplant centres due to higher costs for dedicated diagnostic slots, they should be considered since many donors are young and busy. Test variations exist, with some centres using eGFR plus CT instead of DMSA scans or ultrasounds to estimate split function, influenced by funding arrangements. Video calls are sometimes used for surgical assessments. For kidney sharing schemes, centres conduct initial ABO and HLA typing at the first visit to prevent delays, anticipating donor compatibility issues.

Delays, often caused by interfacing with departments like cardiology, frustrate donors. One centre offers same-day visits for nephrology and transplant surgeons but faces challenges if the surgeon works elsewhere. There was a suggestion to delay blood group and tissue typing analysis.

Concerns that about risk of inflexible pathways deterring donors by lowering their sense of security.

Questions arose regarding whether equipment costs were included in the carbon diagnostic costs and if travel assumptions were based on car use.

Recognising donor variability, there is an ideal for local testing options and choices for in-person or online consultations to reduce contact frequency. Equity access issues were discussed, particularly for financially constrained donors, stressing the need for localised testing.

Although out of scope for this project, we discussed the psychological evaluation for the non-directed donors and whether this needs to be compulsory for all non-directed donors. If so, could it be done online potentially.

What causes the variations between services?

Digressions from the mapped pathway occur due to:

- Improperly labelled blood samples
- Missed transport from hospital to lab, delaying testing
- Additional transport to another hospital for logging, risking timely testing if connections are missed
- Inexperience of non-specialist nurses leading to missed transports, potentially once a week
- Donors unaware of appointment logistics may arrive late, risking missed diagnostics

As a result, donors may need extra appointments for re-sampling or re-testing. Blood results are usually mailed to transplant nurses for logging; delays in this process, especially if the nurse is unavailable, can impact transplants, particularly for directed donors.

Resistance to adopting new practices, like ultrasound, varies among teams, while the implementation of blood testing changes remains unclear. Clinical reasoning and priorities differ, affecting processes such as CT angiography.

Peripheral centres are influenced by funding decisions, and a strong "this is how we've always done it" mentality prevails, despite a desire among transplant coordinators to learn from other services.

Differences also exist between rural and urban centres, with urban centres benefiting from reduced travel distances and carbon footprints.

Issues with digital systems hinder local testing capabilities. Certain specialized tests, such as Measured GFR, aren't conducted at local hospitals or GP practices. Concerns over radioactive materials sometimes prevent performing diagnostics on the same day, leading to potential repeat tests at regional hospitals due to quality issues.

Donor engagement is crucial; maintaining relationships through face-to-face appointments can enhance motivation.

What could be changed?

- Improve communication by ensuring IT systems can interoperate, as seen in the Bradford-Airedale collaboration, driven by departmental requests.
- Establish one-stop shops for donor coordination, balanced with travel considerations.
- Position transplant centres strategically to minimise donor travel distances.
- While patients may prefer face-to-face interactions, more telephone communication can be effective.
- Explore local immunology options for better patient experience, with a focus on sustainability.
- Address logistical challenges in primary care, as it may increase pressures and pushback.
- Consider mobile transplant teams to enhance patient access, though batching could complicate logistics.
- Determine feasibility of independent assessments virtually to streamline processes.
- Optimise donor logistics, primarily focusing on blood transport efficiency.
- Create quicker pathways for specialty referrals and establish one-stop clinics, despite slot protection challenges.
- Investigate alternatives to requiring donor visits for final cross-match within 2-4 weeks of surgery.
- Increase donor pathway completion by fostering collaboration between recipient and donor teams, addressing non-compatibility and health-related dropouts.
- Prioritise transplant donation through focused funding, resources, and staffing, engaging hospital executives in the process.
- Reduce face-to-face visits by expanding virtual appointments while maintaining significant reviews for engagement, especially for non-English-speaking communities.
- One-day appointments may be challenging depending on centre restrictions; consider relocating donors to nearby transplant centres.

Who should lead future improvement work?

- Changes must occur at all three levels: local, regional, and national.
- Local: Implement changes at the departmental level.
- Regional: Establish networks and specialist commissioning for coordination.
- National: Endorse and promote best practices.

- Trusts operate autonomously but require central oversight from bodies like NHS England or NHS BT for governance.
- Clinical networks lack funding.
- Engage influencers across all levels.
- CSH effectively facilitates collaboration.
- Ensure financial resources flow to local leaders and teams.
- Equip teams with practical tools and establish funding pathways to drive changes within trusts.

- Transplant coordinators are crucial for service improvements but struggle to have their voices heard by local MDTs and senior leadership. They need to advocate more forcefully.

- Peer exchanges with other transplant services can provide valuable insights.
- NHSBT's best practice guidance can standardise protocols.
- Finance managers' support is essential to overcome resource barriers, ensuring timely access to necessary specialties.

- Currently, responsibility is fragmented across devolved nations and hospitals.

- Living kidney donor coordinators are positioned to lead change but need robust direction from senior leadership and policymakers for a cohesive framework.
- A specification for the living kidney donor pathway is expected next year, though details remain sparse.
- Consider incorporating psychological assessments for donors, as expertise may be lacking amid overloaded mental health services.
- Independent donor-receptor assessments present challenges; initial face-to-face meetings can be followed by virtual connections to alleviate burdens.

How could changes be implemented

- Secure buy-in from budget holders: Consider the overall treatment pathway for end-stage kidney disease, recognising that while dialysis is funded more generously due to its life-saving impact, kidney donations are also critical investments.
- Promote cultural change: Many parents hesitate to donate kidneys, preferring deceased donor options first. We need to encourage proactive living donations.
- Expand donor pool awareness: Inform potential non-directive donors about the financial contributions they make to the NHS by donating kidneys.
- Offer options: Allow potential donors to choose appointment types, such as face-to-face meetings that include insurance considerations.
- Gather feedback: Send exit surveys to those interested in kidney donation who did not proceed.
- Reduce delays: Minimise the time from inquiry to first appointment, while preparing non-directed donors for potential wait times as a commitment test.
- Incentivise improvements: Financial incentives could fund additional consultants, with savings allocated for better patient outcomes and sustainability.
- Foster collaboration: Engage all stakeholders in the kidney donation pathway, learning from successful examples shared by coordinators like Dawn and Michael.
- Address barriers: The primary obstacles are resistance to change and funding issues. Suggested leadership from commissioners and ICBs should be paired with discussions involving health professionals, patients, and potential donors to set clear targets.

What learning could be shared with other pathways?

- Identify unnecessary diagnostics/tests and unwarranted variation. Consider centralising specialist procurement for all pathways, such as radioactive isotopes.
- Renal: substantial progress made.
- Other Kidney donor areas.

- Living liver donor pathway.
- Broader applications.

- Explore international practices for improvement.

- Participants noted that while some pathways are rigid, the Living Kidney Donor (LKD) pathway is more flexible. A comparable pathway is needed for analysis. Additionally, LKD could improve its psycho-support provisions, learning from better-performing pathways.
- Method of identifying unwarranted variation, diagnostics/tests which might not be necessary
- Some specialist procurement could be centralised for all pathways, e.g. purchase of radioactive isotopes

Other key points

- politicisation of NHS is a problem
- positive variation and negative variation are important to separate out

Geography of participants

Appendix C: case load data

Caseload data

The table below provides caseload data from the 3 assessment sites. Due to the time constraints of the project the data obtained across the sites varied. Includes all new admissions onto the potential donor caseload for the dates below:

- Bradford/Leeds –January 2023-December 2023
- Cardiff/Swansea – April 2024-August 2024
- Belfast – April 2023-April 2024

	Bradford/Leeds	Cardiff/Swansea	Belfast
Number of donors on pathway	89 enquires (Jan 2023 – Dec 2023) 57 (64%) responded to the questionnaire	42 potential donors (Apr 2024 -Aug 2024)	95 potential donors (Apr 2023 – Apr 2024)
Total donated	Of number above, 10 (11%) of those enquired donated	-	60 (63%) donated (to date)
Pre-emptive donation	Of those that donated 3 were pre-emptive (30%) Donor assessment is shared responsibility with transplant centre. 31% at Transplant centre were pre-emptive transplants (Information from the NHS BT annual report, 1 April 2023 – 31 March 2024)	- Donor assessment is shared responsibility with non-transplant centre. 33% at Transplant centre were pre-emptive transplants Information from the NHS BT annual report (1 April 2023 – 31 March 2024)	- All assessments performed in transplant centre. 47% at Transplant centre were pre-emptive transplants. (Information from the NHS BT annual report, 1 April 2023 – 31 March 2024)
% Unsuitable/withdrew	36 (62.5%) of **responders** were unsuitable/withdrew	-	13 (14%) of potential donors unsuitable/withdrew.
When in pathway withdrew/ reasons	No data re exact points in pathway when withdrew Biggest drop out at initial health questionnaire Donor complications - 6 Donor withdrew - 5 DCD / Alt. transplant - 6 Incompatible – 3 Recipient withdrew – 3 Blank-	No exact data re points in pathway when withdrew Biggest drop at initial health questionnaire and at initial face to face appointment. CT scan is also drop out point. Usually drop out due to medical reasons.	No exact data re points in pathway when withdrew Biggest drop at initial health questionnaire. Medical reasons picked up through Ax- 6 DCD transplant - 2 Recipient refused - 1 High risk surgical review - 1 Recipient withdrew – 3
Demographic information	Of those seen in clinic: Gender: 24 M, 19 F Age: 18-44 (20) ,45-54 (10), 55-64 (6) 65-74 (6) 75+ (1) Ethnicity 6 white, 3 Pakistani, 1 other, 33 unknown	-	-

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