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# Environmental impact of Emergency Services in Public Health: an assessment tool

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*Impacto medioambiental de los servicios de Urgencias en la Salud Pública: una herramienta de valoración*

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## ABSTRACT

**BACKGROUND //** Climate change is directly related to increasing medical conditions such as cardiovascular, respiratory and/or infectious diseases, as well as malnutrition and mental illness caused by the reduction of available food and the growth of situations with significant emotional impact, respectively. Evidence showed that healthcare services are responsible for 4-5% of the greenhouse gas emissions worldwide. The aim of this study is the development of an assessment tool to evaluate the carbon footprint of emergency departments.

**METHODS //** The development of the proposed assessment tool followed five stages. Firstly, the categories of GHGs to be included in the assessment tool were determined through a literature review. This was followed by the establishment of scopes and boundaries, selection of conversion factors, data collection from the Emergency Department at the Royal Free Hospital in London as a pilot site, and finally, the development of methodology to assess the carbon footprint.

**RESULTS //** The assessment tool was divided in three scopes and each scope included one or more categories containing several items. Data was collected from different sources such as meters invoicing and billing, auditing, and surveys. The tool is presented in a *Microsoft Excel* document.

**CONCLUSIONS //** This carbon assessment tool offers an opportunity to monitor carbon emissions in emergency departments, aiming to proliferate environmental strategies. The assessment tool seeks to provide a baseline carbon footprint assessment, identifying carbon hotspots within the department. The identification of these areas of intensive carbon emissions can help guide and focus local environmental initiatives that can later be monitored with a follow-up assessment to evaluate their effectiveness.

**KEYWORDS //** Carbon footprint; Greenhouse gases emissions; Emergency departments; Life cycle assessment; Environmental impact.

## RESUMEN

**FUNDAMENTOS //** El cambio climático está directamente relacionado con el aumento de ciertas patologías como enfermedades cardiovasculares, respiratorias y/o infecciosas, así como con la desnutrición, provocada por la reducción de los alimentos disponibles, y el deterioro de la salud mental. La evidencia ha señalado que los servicios sanitarios son responsables del 4%-5% de las emisiones de gases efecto invernadero en todo el mundo. El objetivo de este estudio fue diseñar una herramienta de evaluación de la huella de carbono de los servicios de Urgencias.

**MÉTODOS //** Se diseñó la herramienta a través de cinco etapas. En primer lugar, se seleccionaron las categorías a incluir en la herramienta desde una revisión de la literatura. Posteriormente, se determinaron el alcance y límites, se seleccionaron los factores de conversión, se recopilaron datos del servicio de Urgencias del *Royal Free Hospital* de Londres como sitio piloto y se seleccionó el método de cálculo de la huella de carbono.

**RESULTADOS //** La herramienta resultante se dividió en tres ámbitos, y cada ámbito en una o más categorías que contienen varios elementos. Los datos se recopilaron de diferentes fuentes, como facturación, medidores, auditorías y encuestas. La herramienta se presentó en un documento de *Microsoft Excel*.

**CONCLUSIONES //** Esta herramienta de evaluación de carbono ofrece una oportunidad para monitorear las emisiones de carbono en los servicios de Urgencias. Pretende proporcionar una valoración de la huella de carbono de referencia, identificando puntos críticos de emisión dentro del servicio, que puede dar lugar a iniciativas ambientales locales.

**PALABRAS CLAVE //** Huella de carbono; Emisiones de gases efecto invernadero; Servicios de Urgencias; Evaluación del ciclo de vida; Impacto medioambiental.

## INTRODUCTION

CLIMATE CHANGE CAN BE DEFINED AS THE shift in temperatures and weather patterns secondary to increasing greenhouse gas emissions released into the atmosphere by human activity (1). Greenhouse gases (GHGs) are gases that retain the heat within the earth's atmosphere causing what is called the greenhouse effect, thereby increasing global warming, and changing the Earth's climate (2). Increasing temperature leads to extreme weather conditions such as heatwaves, floods, droughts, and/or environmental hazards (3). Furthermore, climate change is directly related to increasing medical conditions such as cardiovascular, respiratory and/or infectious diseases, as well as malnutrition and mental health caused by the reduction of available food and the growth of situations with significant emotional impact, respectively (4). In 2022 alone, 7.6 million people were displaced in Pakistan due to floods (5). An increase of 68% of heat-related deaths caused by heatwaves was also observed between 2000 and 2021 (6). Climate change does also favour the proliferation and propagation of infectious diseases such as dengue, whose favourable conditions for its propagation have increased a 30% in Europe compare to data from the 1950s. Rising temperatures are also provoking earlier floral seasons compared to data from the last 40 years and this is related to an increase of allergens and allergies, currently affecting 40 per cent of the global population. The impact of climate change on people's health is already noticeable and is expected to increase in following years.

According to the 2015 *Paris Agreement*, the greenhouse gases are: carbon dioxide ($CO_2$); methane ($CH_4$); nitrous oxide ($N_2O$); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulphur hexafluoride ($SF_6$); and nitrogen trifluoride ($NF_3$). Carbon dioxide represents 86% of GHGs and it is for this reason that often the literature, including this document, refers to carbon footprint when referring to greenhouse gas emissions although they include the rest of all GHGs (7). *Carbon footprint* can be defined as the best possible estimation of GHG emissions produced by human activity (8). GHGs are classified into direct emissions -those in which an individual or organisation has direct control-, and indirect emissions -those related to the activity of the individual or organization but over which there is not control of the source-. According to the *Greenhouse Protocol* (9), GHG emissions can be divided into three scopes:

– Scope 1: includes direct emissions produced by the organisation, for example emissions secondary to fuel use for heating, use of anaesthetic gases and/or freight of transport.

– Scope 2: includes indirect emissions produced from purchased electricity, and therefore electricity that has been produced elsewhere is beyond the organisation's control.

– Scope 3: includes the rest of indirect emissions that are mainly related to the chain-supply, and in which the organisation has not direct control over.

Carbon footprint analysis can be divided mainly into three different methodologies: bottom-up cycle assessment; top-down cycle assessment or economic input-output analysis; and the combination of the two previous methods, also known as the hybrid model (10). Bottom-up cycle assessment consists of the analysis of the carbon emissions attributed to each element of an item, which are converted into carbon equivalent using a conversion factor. Top-down cycle assessment or the economic model uses the money spent on each item and multiplies it by a carbon conversion factor. The hybrid model combines both models. Estimations are used to calculate the carbon footprint of organisations. It is necessary to quantify the activity that generates carbon emissions and multiply it by a conversion factor, which represents the amount of GHGs emitted by that activity. The unit to measure carbon footprint is $CO_2$eq, using this gas as reference, being the most influential in global warming (11).

Evidence has revealed that healthcare services are responsible for 4-5% of GHG emissions worldwide (12). In 2015, the state members of the United Nations, due to the crisis of the planet as a sustainable space to be home to everyone in a fair and equal manner, established *17 Sustainable Development Goals* to preserve the planet and improve everyone's lives and anticipated to be achieved by 2030 (13). These Sustainable Development Goals include, amongst others: zero hunger, good health and well-being, clean water and sanitation, affordable and clean energy, sustainable cities and communities and climate action. The Sustainable Development Goals are interrelated and configured as a global strategy, since for instance, the goals of reducing tropical diseases or reducing deaths and illness from hazardous chemicals, and air, water and soil pollution and contamination, are directed related to climate action. Climate action targets aim to strengthen climate resilience, integrate climate change measures into national policies, strategies, and planning, improve education and raise awareness, create a Green Climate Fund and promote climate related changes.

The National Health Service (NHS) in the UK was the first health system to introduce net zero policies into legislation, with the objective to reduce their carbon emissions to zero by 2040 (14). The Intergovernmental Panel on Climate Change (IPCC) 2022 report highlights the importance of regional and local initiatives to reduce carbon emissions (15). Local sustainability initiatives in the healthcare field can have a significant impact in reducing carbon emissions and produce a snowball effect in other health services, however evidence is necessary to make a case of these initiatives (8). The *Green Emergency Department* (GreenED) project is an initiative led by the Royal College of Emergency Medicine (RCEM), which aims to reduce the environmental impacts, including greenhouse gases emissions, resulting from activity in the delivery of emergency healthcare services in NHS hospitals.

The development of tools to evaluate the carbon footprint of healthcare services can be a way to provide evidence of the environmental impact of a given activity, and an opportunity to identify carbon hotspots, and to quantify and reduce carbon emissions. The aim of this study is the development of an assessment tool to evaluate the carbon footprint of EDs in the UK.

## MATERIAL & METHODS

THE METHODOLOGY TO DEVELOP THE ED carbon assessment tool followed the following steps:

– Selection of the categories included in the assessment tool, through a literature review.

– Determination of scope and boundaries.

– Selection of conversion factors.

– Data collection.

– Evaluation method of the carbon footprint.

Categories selection. To begin with, the research team conducted a literature review to identify the most common categories previously analysed in carbon footprint assessments papers in the healthcare field. The literature review was carried out using the Medline, Web of Science, CINAHL and Cochrane databases with the key words: *carbon footprint, greenhouse gases, life cycle assessment* and *health*. This literature review revealed that the categories analysed in the selected studies were: energy and heating, anaesthetic gases, freight transport, purchased electricity, catering and food, disposables and consumables, medical and non-medical equipment, pharmaceuticals, transport, waste, and water. The research team considered that all these categories could provide a comprehensive carbon footprint assessment and all of them were included in this study. However, anaesthetic gases and freight transport were adapted for the emergency services context.

Scope and boundaries. The assessment tool has been designed for the period of time that the user considers appropriate. The ED premises for this tool include all areas in which emergency care is provided (such as Minors, Majors, Resus and Same Day Emergency Care (SDEC) ambulatory units) for adults and/or paediatrics. Radiology departments that are shared or exclusively used by the ED are also included. In addition, administration offices that are within the ED premises and that are part of its management and functionality are included. This study does not include building infrastructure, support services (such as financial or other administrative services) and other diagnostic services (such as laboratories or imaging departments such as nuclear medicine or ultrasound departments). Other services such as ambulance services are included as a form of transport, however the carbon footprint originating from activities whilst the patient is in the ambulance (*e.g.*, disposables use) is not included. Laundry services are also not included due to this being a process external to an ED; also there are not specific conversion factors for this activity, making the data inaccessible **(16,17)**.

Conversion factors selection. The emissions factors used for this tool are based on the publication made by the Department for Environment, Food & Rural Affairs (DEFRA). DEFRA provides annual conversion factors for organisations reporting GHG emissions. The data provided by DEFRA offers easy access, most up to date conversion factors and has an international recognition. The only exception was in the category of waste, as DEFRA does not provide specific data for the waste streams of health services; in this case conversion factors provided by Rizan *et al*. were used **(18)**.

Data collection. Data sources were identified in the literature review and the research team carried out a key data collection, creating an inventory of items for each category. The ED at the Royal Free Hospital in London was selected as a pilot site for the identification and collection of data between November 2022 and February 2023. Data were collected by observation and hospital records. *Microsoft Excel* for *Mac* Version 16.25 was used for the organisation of collected data and calculations.

- Energy, heating, purchased electricity and water. Data regarding energy, heating, electricity, and water are usually obtained from meters, however specific submeters for EDs are rarely available. For this assessment tool, the approach used by Prasad *et al.* **(19)** was adopted, according to which the total consumption of the site is multiplied by the department's surface and divided by the total surface of the site. This formula can provide an estimation of the department's consumption and subsequently its carbon footprint. This data can be obtained from supplier companies or the administration team through billing records. Specific use of green energies sources was not included in the calculator; however, the use of green energies is applied in the conversion factors provided by DEFRA, hence the increase of green energy use will decrease the conversion factor.

- Anaesthetic gases. It was observed that anaesthetic gases are rarely used in ED and, when used, are normally managed and ordered by the anaesthetics team rather than emergency practitioners. Hence, this category only included nitrous oxide and methoxyflurane that are often used as short-acting anaesthetsic agents in EDs.

- Freight transport. Freight transport was excluded from our assessment tool. Freight transport is often controlled by the organisation rather than individual departments, hence the analysis of specific freight transport for EDs is not accessible and feasible for this study. However, the transport of patients to different sites within a trust are included in this category, as they represent direct emissions controlled by the department. Interhospital transport can be defined in this study as the transport of patients between different sites in or different trust due to, for example, requiring specialist input or diagnostic tests that are not available on site. However, ambulance services as a method of transport for patients to go from their house or place of incident to the hospital are categorised as indirect emissions and are analysed in another category.

- Disposables/consumables and pharmaceuticals. The data for disposables or consumables and pharmaceuticals can be obtained from the department's ordering records. Departmental records should include the prices of each item and the number of items ordered either monthly or annually. Due to the large number of items for these two categories, the authors applied a top-down approach for these two categories. Furthermore, medicines that were rarely used and for which the price was less than £1 were excluded since their contribution to the carbon footprint would be negligible; to expedite the calculation, it was decided to exclude them.

- Medical and non-medical equipment. Medical equipment includes a comprehensive list of equipment utilised in ED, such as observation machines, thermometers and ultrasounds. Medical equipment lists can be obtained from the medical devices department. All the medical items provided by the medical devices department were included in this assessment tool. Furthermore, information from manufacturers regarding life expectancy for each item was included.

  Non-medical equipment included were paper, pens, computers, and printers. An audit carried out showed that these items were the most used in ED and therefore were selected for this category.

- Patient and staff transport. Data regarding patient and staff transport can be collected through a survey. The survey must offer a comprehensive list of methods of transport and calculate the distance per return journey from the individual's house to ED. The list of methods of transport includes active transport, cars of different sizes (small, regular and large) and fuel (petrol, diesel, hybrids and electrics), motorcycles, and public transport (bus, tube and train). The survey is anonymous and its participation voluntary and includes the miles between the patient's house or place of incident per journey and the method of transport. The survey will be carried out over a two weeks period and estimations will be made for a year period. Regarding staff, an audit will be carried out including the number of full and part time staff, the mileage per journey and the method of transport. DEFRA provides a comprehensive list of conversion factors for each mile travelled in different methods of transport, such as travel by train, bus, motorcycle, regular diesel or petrol car, amongst others.

- Food and catering. Numbers of meals served in ED can be calculated through auditing. DEFRA provides conversion factors for food and drinks based on weight and cost. Our assessment tool provides calculations based on weight per meal served. Furthermore, several items of catering are included. This assessment tool does not differentiate between vegetarian and non-vegetarian meals and is considered one of our limitations.

– Waste. Waste calculations include recycled waste, domestic waste, non-infectious offensive waste, infectious waste, clinical waste, medicinal contaminated sharps, anatomical waste, medicinal waste, reusable surgical instruments, and batteries. Data can be collected through auditing over a period of time, obtaining the weight of each type of waste. As previously mentioned, DEFRA does not provide these specific conversion factors, hence the conversion factors provided by Rizan et al. are used **(18)**. Rizan *et al.* carried out a carbon footprint assessment of the waste in three different hospitals of the UK, producing a list of conversion factors for healthcare waste through the obtained data. The NHS database provides the expenses secondary to hospital waste and hence, allows the calculation of each type of waste, which Rizan *et al.* used in their study. Rizan *et al.* included in their study the transportation of waste between the hospital and the waste plant, the energy and water used to process waste, and direct emissions. The method for waste disposal was carried out in three groups: autoclave, heat waste or incineration and recycling.

Evaluation method of the carbon footprint. Our assessment tool uses a hybrid method to quantify the ED carbon footprint, combining bottom-up and top-down life cycle assessments depending on the availability and accessibility of the data collected. The assessment of energy and heating, anaesthetic gases, electricity, catering and food, transport, waste, and water related carbon emissions are calculated through a bottom-up approach, whereas the rest apply a top-down or financial model.

## RESULTS

OUR PROPOSED CARBON FOOTPRINT assessment tool for EDs is divided in three scopes and each scope contains one or more categories containing several items **[Table 1]**. The categories selected are energy and heating, anaesthetic gases, interhospital patient transport, purchased electricity, catering and food, disposables and consumables, medical and non-medical equipment, pharmaceuticals, transport, waste, and water. Data is collected through four different sources: meters (*e.g.*, energy meter or water meters), invoicing and billing, auditing, and survey. Key data is obtained from each category over a period of a year. Assumptions are made in the categories of energy/heating, electricity, and water when submeters are not available, however the user is able to introduce exact values if submeters are present. Furthermore, the categories of catering and food, and waste are audited over a week and values extrapolated from that calculation.

The tool is presented in a *Microsoft Excel* document. The user can navigate the Excel and introduce the amount required for each item when available. The amount introduced is multiply by a conversion factor that originates the amount of carbon emissions. Most of the data can be obtained directly from the service, however, there is some data regarding energy, electricity and water use that will likely need to be obtained from the Estates Management team or ERIC database.

## DISCUSSION

THIS CARBON ASSESSMENT TOOL OFFERS an opportunity to monitor carbon emissions in EDs, with the aim to develop environmental strategies to reduce carbon emissions. The assessment tool seeks to provide a baseline carbon footprint, identifying carbon hotspots within the department. The identification of carbon hotspots or areas of high carbon emissions can lead to local environmental initiatives that later can be monitored with a follow-up assessment to evaluate their effectiveness. The development of the tool is not only beneficial for the Emergency Department but can also incentivise the development of similar tools in other healthcare fields **(20)**.

Our study is similar to the calculator previously made by Sawyer, who developed a calculator for GP practices in the UK **(21)**. The GP calculator divides the carbon footprint into three areas: operational (including energy use, travel, professional services, and other activities such as procurement, office and medical consumables, water and waste), investigations and pharmaceuticals. Sawyer highlighted the importance of deve-

Table 1
Contents of the ED carbon footprint asessment tool.

| Scope | Categories | Data sources | Key data collected | Example of items | Conversion factor | Unit |
|---|---|---|---|---|---|---|
| 1 | Energy and heating | Invoicing and billing, Energy meters | Annual consumption(*) | Natural gas, burning oil, green energies, etc. | DEFRA database(**) | Litres, kWh |
| | Anaesthetic gases | Invoicing and billing | Annual consumption | Nitrous oxide and methoxyflurane | DEFRA database | £ |
| | Freight transport | Practice inventory/ auditing | | Patients transport between different sites | DEFRA database | |
| 2 | Electricity | Invoicing and billing, Electricity meters | Annual consumption(*) | Electricity consumption | DEFRA database | kWh |
| 3 | Catering and food | Practice inventory/ auditing | Number of meals per patient | Meals, sandwitches, milk, fruits, biscuits, etc. | DEFRA database | Kg |
| | Disposables and consumables | Practice inventory/ auditing | Inventory of disposables and consumables | Office consumables such as tones, paper, batteries, clothing, etc.<br>Medical consumables such as couch rolls, aprons, gloves, blood sample tubes, cannulas, catheter, disposable incontinence, etc. | DEFRA database | £ |
| | Medical equipment | Practice inventory/ auditing | Inventory of medical equipment | Miscellaneous medical equipment (stethoscopes, thermometer, pentorch, electrical equipment and machinery, electrical items) | DEFRA database | £ |
| | Non-medical equipment | Practice inventory/ auditing | Inventory of non-medical equipment | Computers, trolleys, beds, metal equipment, pillows, etc. | DEFRA database | £ |
| | Pharmaceuticals | Practice inventory/ auditing | Annual consumption | Injectables, fluids, tablets, creams, nebulizers, inhalers, eyedrops, etc. | DEFRA database | £ |
| | Transport | Survey | Survey to patients, relatives, and staff. Mean of transport and distance | Transport of patients, relatives and staff. Includes means of transport such as active transport, carrs by size (small, medium and large) and combustible (petrol, diesel, LPG, hybrids and electrics), motorbikes and public transport (bus, tube and train) | DEFRA database | Km |
| | Waste | Invoicing and billing, Practice inventory/ auditing | Inventory of waste | Recycling, domestic, non-infectious offensive, infectious, clinical, anatomical, and medicinal waste | Rizan *et al.*[16] | Kg |
| | Water | Practice inventory/ auditing, Water meters | Annual consumption(*) | Water consumption | DEFRA database | $m^3$ |

**(*)** If data not available specifically (sub-metered) for the department, total use for the hospital will be divided by the sqm of the department; **(**)** Department for Environment, Food & Rural Affairs (DEFRA).

loping these assessment tools to meet national reduction targets. Furthermore, carbon footprint calculators could lead to positive actions such as establishing key priorities, changing behaviours, recognising the benefit of action, and influencing others to carry out green initiatives. Health service for the climate (*Sanidad por el clima* in Spanish) is a platform that was created as a result of COP25 in 2019 and that has recently developed a free carbon footprint assessment tool for healthcare organisations in Spain **(22)**. Their assessment tool incorporates similar categories that our assessment too, however, leaves out some other categories such as medical equipment and consumables that we considered important in our study. Nevertheless, their assessment tool is designed to help organisations as a whole and hence, it is not adapted to a more detailed service such as Accident and Emergency. Other calculators such as the one proposed by the Ecologic Transition and Demographic Challenge ministry (Spain) facilitate the calculation of scope 1 and 2 emissions, however it does not calculate scope 3, which it is considered of great relevance in the development of local initiatives within healthcare professionals **(23)**.

Local initiatives have proven the potential of significant impact in the reduction of carbon emissions in EDs. A multidisciplinary team carried out a project to reduce unnecessary cannulation in an ED at Charing Cross Hospital in London **(24)**. A baseline audit revealed that 86 per cent of the patients attending ED were cannulated and 40 per cent of those were not used. The team led a project to educate, raise awareness and encourage staff to change behaviour towards unnecessary cannulation, highlighting the cost and environmental impact of those actions. A follow-up audit showed a 25 per cent reduction of cannulation in ED, suggesting a potential reduction of 19,000 kg/$CO_2$ per year and saving around £95,000. Furthermore, Manchester University NHS Foundation Trust, which sees about 2 million visitors per year and employs over 20,000 staff, carried out a sustainable travel programme to encourage people to use more sustainable and active travel options **(25)**. The programme focused on increasing bus use, reducing single-occupancy car journeys, and increasing walking and cycling as method of active transport. To accomplish these targets, the trust improved their infrastructure with more cycle parking spaces and extra electric vehicles charging points and offered discount schemes for travelling amongst other initiatives. These measures resulted in a 40 per cent increase of more sustainable transport use amongst the staff in the trust.

Similar initiatives have also been developed in Spain. Infanta Elena hospital in Huelva reduced their GHG emissions 36 per cent, from 3,070 tonnes of $CO_2$eq in 2019 to 1,130 $CO_2$eq in 2020, thanks to a campaign to improve the management of fuels. Petrol boilers were replaced by natural gas, which has a coefficient of less than 40 per cent. Furthermore, there was a 13 per cent reduction in natural gas consumption for heating and hot water as consequence of responsible use, adapted to the time of the day and needs of the service, and the isolation of windows and doors to preserve better the temperature **(26)**. In 2021, Gregorio Maranon hospital in Madrid launched a sustainable management plan to reduced single use plastics, eliminating the purchase of plastic tableware and replacing it with biodegradable materials. This resulted in a reduction of 217,000 straws, 21,700 trays, 668,200 spoons, 102,300 knives, 139,900 forks, 229,300 plates and 256,550 cups. Furthermore, the bin bags wereare made from 100 per cent recycled material **(27)**.

The limitations of the current study include, first of all, the estimations in the calculation of carbon emissions in some of the categories that could influence the obtained results. The consumption of energy and heating, electricity or water could not be collected through direct meter readings, which might affect the calculated carbon footprint. Furthermore, the research team acknowledged that the bottom up LCA approach would provide more accurate data, especially for categories such as consumables and pharmaceuticals, however, this methodology is not feasible for some of the categories in this study. Equally, there is possible uncertainty associated with the reliability of the conversion factors. In relation to the data regarding transportation of patient, since it is collected through a survey completed by the users, it must be recognised that there is bias associated with the representativeness of the sample, and the information provided.

As a conclusion, our research team proposes a comprehensive carbon footprint assessment tool for EDs. This initiative highlights the importance of assessing carbon emissions in healthcare units in order to carry out environmental initiatives in line with the UN sustainability goals and national net zero policies. This tool is the first carbon footprint assessment tool specifically for EDs, available for free access. Its use will allow EDs to calculate their carbon footprint in a standardised and efficient manner. Furthermore, the use of this tool can lead to raised awareness, increase climate resilience, and promote climate action by patients and staff. This study facilitates the production of robust evidence to back up environmental initiatives and presents an opportunity for further research.

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