**TERMS OF REFERENCE FOR INDIVIDUAL CONSULTANTS**

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| **Purpose of Activity/Assignment:** UNICEF requires the services of an external consultant to design, develop, test and deploy machine learning models to enhance the efficiency and effectiveness of vaccine stock management systems, subnational distribution strategies, planning processes, track adherence to stock management protocols, and strengthening vaccine accountability standard operating procedures (SOPs) through the active use of data for planning and decision-making.The consultant will support UNICEF's Program Group Immunization Division (PG-I) in optimizing vaccine supply chains, ensuring that life-saving vaccines reach every child, regardless of geographical or logistical challenges.The consultant will liaise with the Data, Analytics, Planning and Monitoring Division (DAPM) and with Program Group Immunization (PG-I) to deploy robust machine-learning models within the UNICEF Azure cloud environment. These models will analyze complex data sets, process natural language protocols, optimize subnational distribution routes and schedules, and predict stock risky situations across supply chains, thereby minimizing waste and ensuring timely delivery. By integrating innovative data-driven solutions into country office’s supply chain operations, this assignment aims to strengthen the organization's ability to deliver vaccines more efficiently and equitably, ultimately contributing to improved immunization coverage and the health of children worldwide. **Background** Strong and resilient health supply chains save lives. They are the cornerstone of efficient healthcare systems and a driving force for improving equity, quality, and access to essential services and products. Effective stock management is a critical link in this chain, ensuring access to life-saving products when and where required.Access to updated, reliable, and actionable data enable managers across supply chains to make data-driven plans and decisions, resolve operational challenges, ensure equitable distribution, prevent stockouts, minimize wastages, strengthen vaccine accountability, and amplify the overall impact on health outcomes. However, country data landscapes, digital dexterity, absence of end-to-end electronic Logistics Management Information Systems (eLMIS), financial and human resources gaps and the multitude of digital tools have complicated access to the right information at the right time. The knock-on effects of the COVID-19 pandemic and related vaccination drives exacerbated existing strains on immunization supply chains, reversed hard-earned gains, accelerated outbreaks, multiplied zero dose and under-immunized population, and further highlighted the need for data-driven policies, plans and decisions. To resolve these challenges, UNICEF launched Thrive360, deployed expert technical assistance and developed the Data Control Towers among other initiatives. The team is aiming to deploy cutting-edge machine learning techniques to predict and prevent risks in immunization supply chains. **Thrive360** is a data integration and analytics hub. Launched to closely monitor stock performance, it expanded subnational visibility, highlighted causes and drivers of stockouts, assessed the impact of stockouts on vaccine availability, and integrated supply data with demand, consumption, zero-dose, coverage, and country mitigation efforts. Thrive360 has created stock visibility in over 7,000 subnational stores and plans to expand to 10,000 by 2025.**Data Control Towers (DCT)** is a country-facing data analytics and visualization platform built on Thrive360 and DHIS2. It aims to bridge a critical, long-standing gap in access to validated, most recent, integrated, and granular information from the central store all the way to the health facility. The DCTs enable managers to: * Create end-to-end stock visibility (from central store to health facilities) and assess the order pipeline
* Measure the impact of stock performance on coverage rates, zero-dose, EVM assessments and other relevant indicators.
* Conduct predictive analytics to prevent stockouts.
* Project stock coverage times, shortfalls, and surpluses.
* Monitor consumption patterns.
* Integrate admin data (HMIS, DHIS2, others) with surveys (MICS, DHIS, CES,).
* Cluster areas based on stock performance.
* Track frequency, trends, causes, and duration of stockouts.
* Track districts with high concentrations of zero-dose children and overlay stock performance and coverage data to monitor progress against targets.

Furthermore, UNICEF deployed more than 90 **Vaccine Management Specialists** (VMS) across 45 high-impact countries to bridge the critical human resources gap, build capacities, and strengthen planning, monitoring, in-country distribution, and vaccine accountability. In addition, the VMSs provide critical support with data visibility, management and use, feedback loops, and country mitigation efforts to address supply chain weaknesses and provide on-the-job training.To consolidate the gains, address the outstanding barriers, and leverage the full potential of data used for planning and decision-making, the Programme Group Immunization team and the DAPM’s Frontier Data and Tech Unit are planning to deploy machine learning models, artificial intelligence solutions, and synthetic data on Thrive360 and Data Control Towers. For example, machine learning models can leverage historical stock performance data to identify patterns, outline trends, and predict stockouts, surpluses, and wastages. |
| **Scope of Work:****Plan on how to use the existing data sources together**Data sources available include vaccine and devices stocks (opening and closing balances), vaccine movement (new arrivals, distribution, wastage), forecasted demand (including at subnational levels), allocations, consumption (actual, forecasted, mean and target population), min/safety and max quantities of vaccines by supply chain level and by cold store, pipelines, causes and drivers of stockouts, country mitigation measures, outcomes of country engagement activities, coverage rates, number of zero-dose children, frequency and duration of stockouts, RTM Maturity model data, Cold Chain Inventory Data, EVM & Improvement Plans, Carbon Footprint data for the immunization programme, Waste Management Assessment Data and health Facility solarization Data. There is a need for an initial plan on how we use all the data sources together to strengthen supply chain planning and prediction models. The goals of the prediction models are:* Predict, alert and prevent/reduce stockouts by at least 50%.
* Develop dynamic traffic light system for push-pull intervals and continuously optimize the process through supervised and unsupervised learning.
* Bridge data gaps using synthetic data.
* Project stock coverage times based on consumption patterns, target population and coverage rates
* Predict overstock
* Develop a traffic light system for push-pull intervals by projecting time required to distribute vaccine from central store to the last mile.
* Explore the relationship between safety stocks, procurement leadtime, in-country distribution intervals and service disruption
* Highlight risks of wastage (expiries, breakages, temperature excursions)
* reduce carbon footprint
* improve supply chain planning and replenishment
* manage changes in vaccine formulations
* improve vaccine introductions
* Enable predictive maintenance of cold chain equipment

 **Develop, test, pilot and deploy robust machine learning (ML) models** * ML models should be built on top ofThrive360 and the Data Control Towers, using the data sources mentioned above
* ML models must be built iteratively and incrementally, according to the Scrum Agile methodology, increasing the accuracy and the scope after each iteration
* The code must be written in Python
* ML models must be highly accurate, agile, scalable and adaptable. This requires a thorough evaluation of the accuracy, applicability and performance of the models using industry-standard techniques and literature.
* ML models must fit for low data availability settings, inadequate data quality scenarios and where data is not available on a regular basis.
* ML models can rely on well-known ML techniques like (but not limited to) reinforcement learning, linear regression, supervised and/or unsupervised learning, logistics, Decision-making and/or clustering models.
* ML models must be deployed on the UNICEF Azure infrastructure, therefore the tools and the solutions adopted must be compatible with the deployment on the UNICEF Azure cloud and should be pre-approved by the supervisor.
* ML models must be documented, including methodologies, algorithms, tools, services, and infrastructure.
* ML models and all the code related to them must be organized and stored in UNICEF git repositories, and UNICEF maintains the intellectual property on them

**Collect, clean, assess, preprocess SC data, and train ML model(s)*** Stock performance: collect opening and closing stock balances, new arrivals, pipeline orders, distribution, wastage and consumption by antigen, supply chain level and node.
* Causes of stockouts: obtain causes and drivers of stockouts as well as mitigation efforts by antigen and supply chain levels.
* Coverage rates: from admin sources such as Health Management Information Systems (HMIS) and surveys like Multiple Indicators Cluster Survey (MICS), Demographic Health Survey (DHS) and Coverage evaluation.
* Assess the impact of product changes and new vaccine introductions on supply chain performance
* Demand forecasting: historical forecasting and forecasting accuracy data, target population and allocation levels.
* Assessments: Effective Vaccine Management (EVM) assessment findings, independent monitoring and third-party evaluation data.
* Synthetic datasets: in consultation with subject matter experts, generate synthetic datasets to fill the critical gaps in datasets, speed up model training and improve accuracy.

Building a web application with a user interface is outside the scope of this consultancy.  |
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| **Child Safeguarding** Is this project/assignment considered as “[Elevated Risk Role](https://unicef.sharepoint.com/sites/DHR-ChildSafeguarding/DocumentLibrary1/Guidance%20on%20Identifying%20Elevated%20Risk%20Roles_finalversion.pdf?CT=1590792470221&OR=ItemsView)” from a child safeguarding perspective?        [ ]    YES    [x]    NO     If YES, check all that apply:                                                                                                                                                     **Direct contact role**[ ]  YES     [x]   NO  If yes, please indicate the number of hours/months of direct interpersonal contact with children, or work in their immediately physical proximity, with limited supervision by a more senior member of personnel:

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 **Child data role**[ ]  YES    [x]   NO  If yes, please indicate the number of hours/months of manipulating or transmitting personal-identifiable information of children (name, national ID, location data, photos):   More information is available in the [Child Safeguarding SharePoint](https://unicef.sharepoint.com/sites/DHR-ChildSafeguarding/SitePages/Amendments-to-the-Recruitment-Guidance.aspx) and [Child Safeguarding FAQs and Updates](https://unicef.sharepoint.com/sites/DHR-ChildSafeguarding/DocumentLibrary1/Child%20Safeguarding%20FAQs%20and%20Updates%20Dec%202020.pdf)   |

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| Work Assignments Overview | Deliverables/Outputs | Delivery deadline |
| Coordinate with stakeholders (PG-I, DAPM) to review available datasets, create a plan on how to use all the available data sources together, what kind of ML models should be developed and why. | Development plan with the strategy to use the data sources, the ML models to be develop, and the ML techniques that will be used | 15/11/2024 |
| Version 1. Develop, test and deploy ML models according to the development plan. * Data gaps, risks, limitations, assumptions, and potential solutions identified (Based on the findings of desk review, highlight data gaps, major risks, limitations and assumptions and propose how these would be resolved to ensure the ML models are robust, fit-for-purpose and highly accurate).
* Suitability of Synthetic Data (SD) use assessed, sources /tools identified, and cost estimates prepared. (Evaluate the viability of synthetic data for model training in the absence of real-world datasets or in cases where the quality of data is ambiguous. This also includes the identification of the most cost-effective and practical SD data generation tools, cost estimates and value-for-money assessment).
* Implementation plan developed and SME consulted (If synthetic data use is deemed useful, prepare a plan of action on the involvement of subject matter experts (SME), evaluation criteria, validation tests and independent third-party verification arrangements).
* iSC ML model(s) developed, thoroughly trained, optimized, tested and piloted.
 | Version 1 of ML models developed, deployed on UNICEF Azure, and tested | 30/12/2024 |
| Integrate the ML models with Thrive360 and the Data Control Towers* Incremental learning channeled back to improve the model(s) (The model(s) learns from its past accuracy rates and leverages the findings to improve future predictions).
* Future-proofed (The model(s) follow industry standards and are flexible to upgrades, stress tests and transitions to new teams. At a minimum, the model(s) must follow best practices in modularization, consistency and versioning).
 | ML models v1 integrated with Thrive360 and the Data Control Towers  | 12/02/2025 |
| Produce a document of the code and the models. All phases of model development including data source assessment, data collection, preprocessing, classification, labeling, training, model architecture, evaluation criteria, accuracy rates and results must be documented. | Documentation produced. | 07/03/2025 |
| Identify areas of improvement and criticalities. Discuss with the stakeholders to gather feedback and additional requirements. Create an action plan for an upgrade of the models or the generation of new models. | Action plan produced | 08/04/2025 |
| Version 2. Review and improve ML models according to the action plan.  | Version 2 of ML models developed, deployed on UNICEF Azure, and tested | 13/06/2025 |
| Integrate version 2 of the ML models with Thrive360 and the Data Control Towers | ML models v2 integrated with Thrive360 and the Data Control Towers  | 10/07/2025 |
| Use the models to produce outputs for managers and country offices:* Predictive analytics developed. iSC ML models enable managers at UNICEF and partners to have access to curated predictive analytics dashboards that predict, alert and prevent stockouts, excess stocks, wastages, and other inefficiencies in stock management.
* Demand forecasting: UNICEF country offices and NLWGs can simulate and improve demand forecasting, especially at subnational levels.
* Dynamic inventory management: Managers can project stock coverage times by antigen, supply chain levels and store using single, multiple or mixed methods (push-pull, target population, vaccination session, consumption patterns or others).
* Agile distribution planning: Managers are able to adjust push-pull or min-max-reorder protocols based on historical stock performance.
* Inferential analysis: Managers can simulate future scenarios based on stock performance. For example, they can assess how improvement in stock management could impact coverage rates and zero-dose and vice-versa.
* Cold Chain Monitoring: ML model(s) are trained to enable predictive cold chain maintenance.
* DRIVE route optimization: The model(s) leverage DRIVE data to optimize vaccine delivery routes, frequency and quantities considering constraints such as vehicle capacity, road conditions, cold chain capacity and delivery deadlines. The algorithms must focus on reducing travel time and costs.
* EVM Assessments: The model(s) must enable managers to find correlations between Effective Vaccine Management (EVM) assessments and stock performance.
* Overall supply chain analytics: The model(s) can produce holistic supply chain analytics. Identify inequities, inefficiencies, bottlenecks and areas for improvement, especially at subnational levels. The model should also be able to assess impacts on product/formulation changes and new vaccine introductions to the supply chain.
* Management matrices: Managers have access to personalized action boards with two to three localized action points to resolve pressing operational challenges in their geographic areas.
 | Outputs produced. | 06/09/2025 |
| Update the documentation, including version 2 of the ML models, all the updated requirements and data sources, a user guide to train the models and to use the models, integration with Thrive360 and the Data Control Towers | Documentation updated. | 15/10/2025 |

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| **Minimum Qualifications required\*:** | **Knowledge/Expertise/Skills required \*:** |
| [x]  Bachelors [ ]  Masters [ ]  PhD [ ]  Other Enter Disciplines**Enter Disciplines: Data Science, Computer Science, Applied Mathematics, and related fields** | * Proven experience in developing, training, and deploying machine learning models, particularly for supply chain optimization or similar logistical challenges.
* Expertise in supervised, unsupervised, and reinforcement learning techniques.
* Proficiency in Python.
* Experience with machine learning frameworks such as TensorFlow, PyTorch, or Scikit-learn.
* Strong experience with deploying machine learning models in cloud environments, particularly Microsoft Azure.
* Familiarity with Azure Machine Learning, Azure Functions, Azure Databricks, or similar services.
* Expertise in working with large datasets, including data cleaning, feature engineering, and data visualization.
* Experience with SQL and NoSQL databases.
* Excellent problem-solving and troubleshooting skills.
* Strong communication and collaboration skills to work effectively with cross-functional teams.

 **Good-to-have Skills:** * Previous experience building robust data pipelines using queueing and stream processing, asynchronous patterns, parallelization, e.g., with PySpark, etc.
* Understanding of vaccine supply chains, including distribution strategies, cold chain logistics, and challenges faced at subnational levels.
* Ability to translate complex supply chain problems into data-driven models and solutions.
* Previous experience in similar consulting roles, particularly in global health or public health contexts, is highly desirable.
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| \*Minimum requirements to consider candidates for competitive process  | \*Listed requirements will be used for technical evaluation in the competitive process |
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