GUIDANCE ON PLANNING THE USE OF BARCODE SCANNING FOR THE INSECTICIDE-TREATED NET (ITN) SUPPLY CHAIN AT THE COUNTRY LEVEL

JANUARY 2026

amp | The Alliance for Malaria Prevention
Expanding the ownership and use of mosquito nets

CONTENTS

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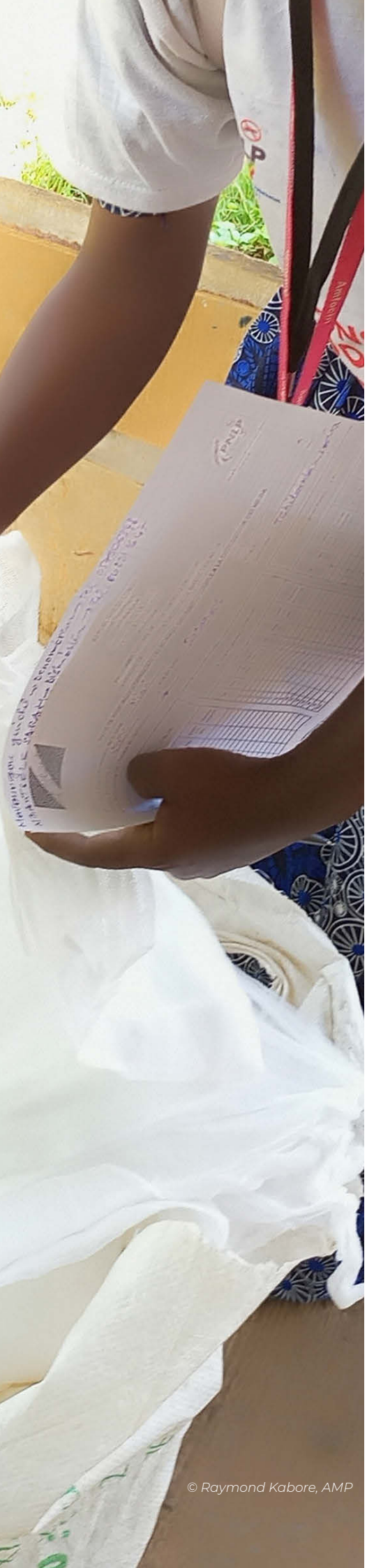

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ABBREVIATIONS

AI	Application Identifier
AIDC	Automatic Identification and Data Capture
eLMIS	Electronic Logistic Management Information Systems
HRI	Human Readable Interpretation
ITN	Insecticide-treated net
GTIN®	Global Trade Item Number
NMP	National malaria programme
SOP	Standard Operating Procedure
SSCC	Serial Shipping Container Code

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1. INTRODUCTION

The vision of having end-to-end supply chain accountability in ITN programming must be paired with an intent to have rigorous processes in place, producing readily available outputs, from which questions such as the following can be answered:

- Did all the ITNs reported as having been shipped by the manufacturer/supplier arrive?
- Did all the bales of ITNs transported to pre-positioning or distribution sites arrive where they were supposed to go?
- Where was a specific bale of ITNs before it arrived at a specified location?
- Where and when did the ITNs get distributed and by whom were they distributed?

ITN programming that can answer the questions above will have improved efficiency, enhanced accuracy, reduced errors, better inventory management, increased supply chain visibility and end-to-end supply chain accountability. These same general benefits and the ability to answer questions such as those posed above are already being achieved in the programming for other health commodities through the use of technologies and systems primarily relying on the incorporation of barcode scanning into supply chain programming.

Technologies that enable supply chain stakeholders to automatically identify objects, capture data about them, and enter those data into information management systems, commonly referred to as Automatic Identification and Data Capture (AIDC), have been in use since the 1970s. Incorporating these technologies and related processes, specifically automatically capturing the machine-readable content on the labels of bales of ITNs, bags containing individual ITNs and individual ITNs with the intent of enhancing traceability, accountability and efficiency, began scaling up in 2021.

This document provides an overview of the barcoding and barcode scanning technologies available for, and in use within, discrete elements of ITN supply chain operations as of 2025. It further elaborates where and under what circumstances the incorporation of these technologies and associated processes should be considered to achieve end-to-end supply chain visibility.

The guidance is presented in the following sequence:

- A highlight of some key characteristics of packaged ITNs and their supply chain programming and illustration of some of the supply chain challenges that have arisen as a result of these characteristics.
- The enablers of AIDC for use in ITN supply chains: details of different ITN barcode (data carriers) formats and their content, bar code scanners and the digitalization applications that manage information captured and shared.
- Where and when to apply AIDC within and across ITN supply chains.

The guidance is principally to be used for planning and conceptualizing purposes by national malaria programmes (NMPs), implementing partners and other stakeholders such as the developers of ITN digitalization tools. It provides insights to ITN stakeholders and partners seeking end-to-end supply chain visibility of what the various technologies are, what they do and the inherent interdependence of the various technologies. The guidance, together with accompanying generic Standard Operating Procedures (SOPs), can assist with more thoroughly coordinated planning that balances an ITN programme's need for both effectiveness and efficiency.

While this document is not intended to be prescriptive, it does contain normative references to standards and good practices with a specific focus on GS1-based global standards for healthcare supply chains incorporating AIDC. GS1 is an international standards organization that develops and maintains a comprehensive system of data standards for supply chains. As of 2025, the Global Fund and other global health organizations have aligned on the use of GS1 standards to enable end-to-end data visibility through globally unique item and location identification and increasingly mature master data management practices, which create opportunities for improved interoperability in global health supply chains.

Current ITN distribution need

ITN distribution is a recurring and extensively implemented public health intervention and has developed a very high public profile. ITN distribution is also an intervention requiring significant and recurring financial inputs, needing corresponding levels of accountability. The interest in reinforcing and strengthening the supply chain component of ITN distribution is stronger now than it has been in the past. In the current climate of constrained resources and reduced funding, national malaria programmes need to make the best use of those ITNs they have to cover the most vulnerable populations and to ensure accountability towards the investment of national governments or external funders, partners and stakeholders in the ITN distribution.

While ITN supply chain programming has improved in a context where supply chains for other public health programmes have also been maturing, it can be further enabled through the increasing use of more complex and sophisticated tools. However, the use of such tools often requires greater planning, coordination, cooperation and a common appreciation of the interdependencies between technologies, processes and the partners primarily managing them. With a holistic appreciation across stakeholders of the technologies and processes outlined in this guidance, current ITN distribution needs can be supported.

2. ITN SUPPLY CHAIN CONTEXT

ITNs can be characterized as:

- Bulky, heavy and requiring intensive material handling effort
- Often similar in appearance when either in bales or removed from their individual bags though varied by brand, size and texture
- Classed as containing pesticide, and consequently having storage and distribution requirements distinct from the majority of other health commodities
- Subject to incidents of leakage and diversion through the general public's familiarity with and interest in ITNs, paired with commercial unavailability in many settings

The ITN supply chain can be characterized as:

- Requiring enhanced tracking and accountability requirements over some other health commodities where distribution and dispensing occur within the rigidity of fixed healthcare dispensing sites
- Requiring many container loads on a voluminous and massive scale being delivered to numerous destinations in a short period of time when distributed through a campaign
- Sometimes having a different or even independent flow through the health system versus other health commodities due to varied distribution channels and frequency
- Involving multiple stakeholders tasked with managing custody transfers, unlike other health commodities where the chain of custody is managed by a single entity such as, for example, the medical stores of a Ministry of Health

Many health commodities encounter similar challenging supply chain contexts such as a poorly maintained road transport network. However, the distinct combination of the characteristics of ITNs themselves and the characteristics of the programming to which they are subject results in a number of challenges and consequences that, although not exclusive to ITN distribution, predominate in this context.

Table 1: *identifies some specific challenges of ITN supply chain management.*

Challenge	Consequence
Inefficiencies in tracking ITN inventory	▪ Manual record-keeping and delayed data exchange can lead to inconsistencies and inaccuracies in reported inventory levels. ▪ Lack of near real-time inventory visibility prevents timely decision-making and stock adjustments. ▪ Bulky and voluminous characteristics make collection and the duration of the collection time consuming and potentially error-prone. ▪ Data fragmentation across systems: different stakeholders may use disconnected systems with critical data widely spread, preventing comprehensive data analysis for decision-making.
Theft, diversion and fraud	▪ Uncertainty in supply chain accountability creates numerous blind spots and opportunities for undetectable product diversion. ▪ Disruptions in distribution decrease the ability to maintain consistent oversight and control. ▪ Intentionally fraudulent activities are designed to compromise data integrity, hinder proper decision-making and exploit the resulting opportunity.

The greatest consequence resulting from an inability to adequately address the unique characteristics of ITNs and specifics of ITN distribution is a breakdown at various stages of planning and implementation, contributing to reduced or insufficient impact on malaria prevention and control resulting from insufficient coverage or unequal access to ITNs.

3. AUTOMATIC IDENTIFICATION AND DATA CAPTURE (AIDC)

AIDC encompasses a wide range of technologies used to automatically identify objects, collect data about them and enter those data directly into supply chain software systems with minimal human intervention. Incorporating the use of AIDC in the scanning of bales and ITNs can reinforce and strengthen supply chain components of ITN distribution.

Table 2: *lists some of the benefits of incorporating AIDC into ITN supply chains.*

Benefits of incorporating AIDC into the supply chain	Rationale
Improved efficiency and productivity	AIDC automates data collection, reducing the need for manual processes which are often time-consuming and prone to errors. For example, scanning a barcode on an ITN bale or individual ITN is much faster and more accurate than manually recording its details.
Enhanced accuracy and reduced errors	AIDC technologies minimize errors resulting from manual data entry, leading to more reliable data.
Better inventory management	AIDC enables real-time tracking of inventory, providing accurate information on stock levels, product-specific dating, batch/lot and the location of materials.
Increased supply chain visibility	AIDC technologies enable end-to-end visibility across the supply chain. This allows ITN distribution stakeholders to monitor the movement of ITNs, identify potential bottlenecks or delays, and ensure the integrity of the supply chain.
Improved accountability, compliance and traceability	Many health programmes require strict accountability and traceability of products, especially health commodities such as ITNs. AIDC technologies facilitate this by providing a clear audit trail of health commodities as they move through the supply chain.

Common AIDC technologies include:

- Linear barcodes: striped codes (commonly seen on groceries)
- 2D matrix barcode: two-dimensional barcode
- QR codes: two-dimensional codes that store information by encoding data both horizontally and vertically
- Biometrics: identifies individuals based on biological traits (e.g. fingerprints, facial recognition)
- Magnetic stripes: found on credit cards and identity badges

Examples of where AIDC is used:

- Retail: point-of-sale systems, inventory management
- Healthcare: patient tracking, medication administration, electronic health records
- Logistics and supply chain: tracking goods, warehouse management
- Manufacturing: production tracking, quality control
- Security: access control, identification

To successfully implement AIDC within and across an ITN supply chain, three enablers must be in place and be capable of working in conjunction prior to the in-country arrival of the first ITN: (1) ITNs and bales labelled with data carriers containing their contents (see Section 4), (2) scanning hardware capable of capturing the data carrier content in the context in which the ITNs will be encountered (see Section 5), (3) operational information management system(s) that will record and manage the data that are captured (see Section 6).

Having a basic understanding of these three enablers and how they interact, which data are captured and conveyed and how they can be further used, is important for NMPs in order to maximize the information carried to implement processes that will ensure both speed, accountability and traceability in their digitalized supply chain.

4. LABELLING

TraceNet recommendations

To further the goal of improving accountability and traceability of ITNs, the US President's Malaria Initiative (PMI) and The Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund) co-convened the TraceNet Working Group in 2019 to seek industry input on developing and implementing AIDC standards. This working group included manufacturers, procurement agents and implementing partners, including representatives from select donor-funded country programmes.

The working group determined that GS1 standards were best suited to accomplish the goal of TraceNet. The working group's Recommended Identification, Capture, and Master Data Sharing Specifications for Long Lasting Insecticidal Nets became a major input for developing the contract requirements implemented by procurement agents for the US Agency for International Development (USAID), Global Fund and other agencies. As many of the ITNs delivered to countries since 2022 have been procured with labels that align with the TraceNet outputs, this guidance makes frequent reference to TraceNet recommendations as the basis for its content.

NMPs embarking on end-to-end supply chain visibility initiatives or those seeking to further improve on current initiatives should note that TraceNet's outputs are recommendations and not specifications and that it is important to coordinate with suppliers and procurers regarding labelling requirements under the terms of any particular procurement.

As of 2025 there are three different labels available:

1. Labels on individual ITNs
2. Labels on individual ITN bags
3. Labels for bales of ITNs

There are some elements of the labels that are common across these three labels and there are some aspects that are unique. The following examples provide more detail.

The individual ITN

The terms "product" and "trade item" are often used interchangeably, but in practice and for the purpose of this guidance, these two terms have different characteristics that are important to understand in order to manage ITNs effectively. In general, a "product" refers to a commodity, whereas the "trade item" refers to a commercialized instance of that commodity by a specific manufacturer. ITNs would be a broad product category. Dual active ingredient (ai) ITNs could be a sub-category of ITNs. An individual ITN, however, is a trade item when it possesses unique characteristics, such as manufacturer, brand name and production date. The trade item is the fundamental unit of management within a supply chain.

Figure 1: *Label on individual ITN (accompanying legend for illustrative purposes only)*

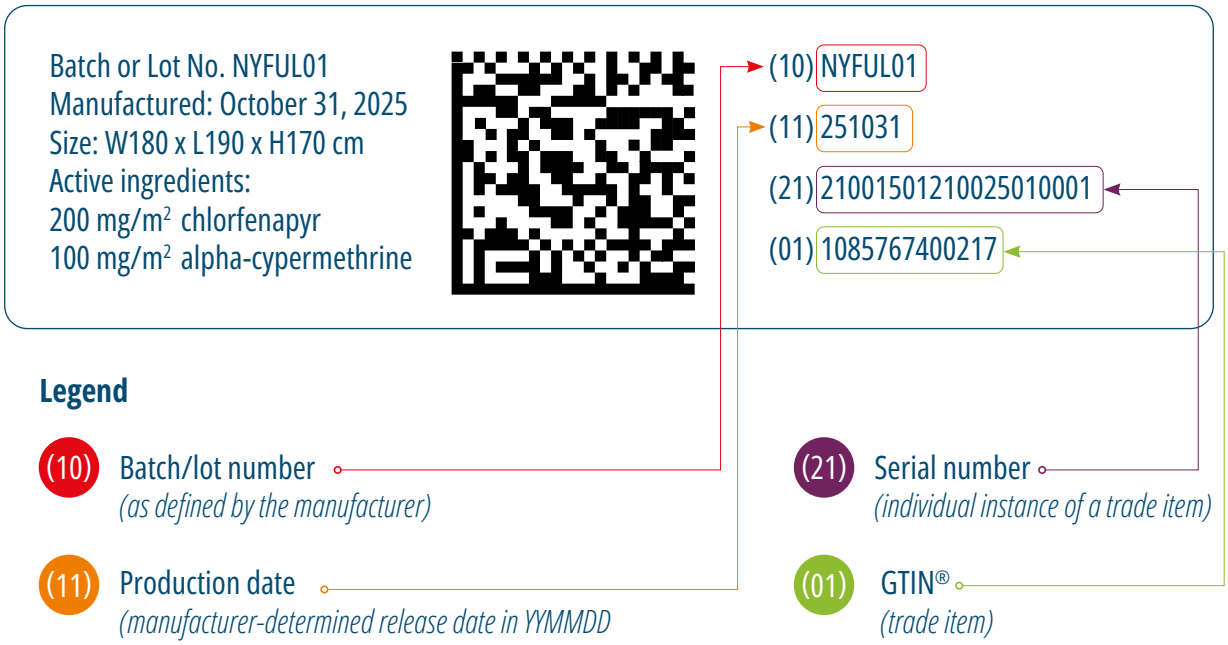
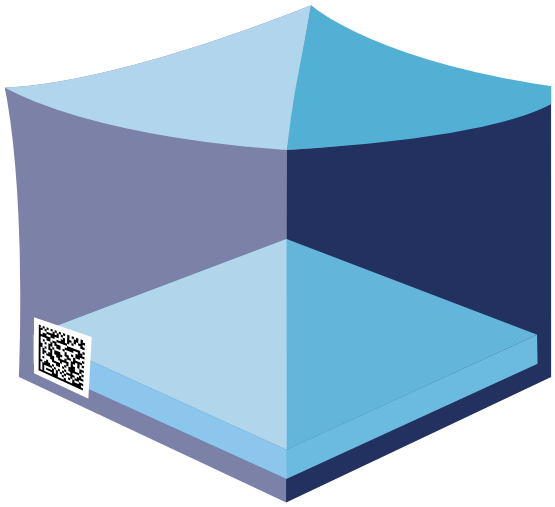


Figure 1 shows what could be found sewn onto a seam of an individual ITN. Data are conveyed both for Human Readable Interpretation (HRI) and for AIDC purposes. The data carrier used in the example is the GS1 2D DataMatrix. TraceNet recommends it as a data carrier for individual ITNs because it provides large data-conveying capacity in a small space and can encode serial numbers and batch/lot numbers within it.

The characters within parentheses on GS1 labels, typically seen in the human-readable text examples above, represent Application Identifiers (AIs). AIs are two-to-four-digit codes that define the type of data being encoded in the data carrier, such as an item number or serial number. The parentheses are included for human readability and are not part of the data carrier's data.



Individual ITN

With the use of GS1 standards, a separate and unique Global Trade Item Number (GTIN®), which is the data string following the (01) in the example above, is required whenever ITNs are different in ways such as brand name, manufacturer name, manufacturer location, shape, dimensions, material, denier, colour, active ingredient(s) and accessories. Furthermore, the GTIN® for an individual ITN packaged in bulk (without an individual bag), or referred to as a "bulk net", should be different from the GTIN® of an individual ITN intended to be distributed when packaged in an individual bag, even if the ITN itself, in both instances, has an otherwise identical product profile.

The GS1 AI-conveyed data recommended by TraceNet for inclusion on the label for an individual ITN is:

(01) GTIN®

(11) Production date

(10) Batch/lot number

(21) Serial number

The ITN serial number identifies an individual instance of a trade item. The unique serial number, as well as the other AI data conveyed (lot/batch, production date), is defined as transactional data.

Bag containing an individual ITN

The TraceNet-recommended type of data carrier for use on an individual bag is the GS1 2D DataMatrix.

The GS1 AI-conveyed data recommended for inclusion on the individual ITN bag are:

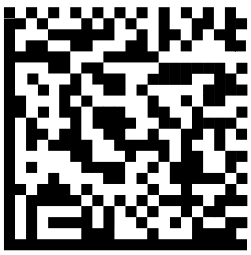
(01) GTIN®

(11) Production date

(10) Batch/Lot

individual ITN bag

Figure 2: *Data carrier on an individual ITN bag*



(10) NYFUL01

(11) 251031

(01) 1085767400217

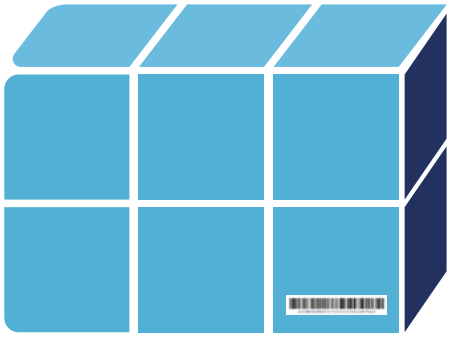
Figure 2 shows the GTIN®, production date and batch/lot as being the same as the example of the data carrier for the individual net label but this label does not include the serial number of the individual net contained within it. From a manufacturing perspective, in late 2024, the matching of serial numbers between individual ITNs and their pre-printed individual bags was considered to be very complicated and potentially requiring additional costs. Some manufacturers have examined ways to have the data carrier of the individual ITN be displayed through a transparent panel of the individual bag so as not to require a data carrier on the individual bag. This option would not, however, be possible for bulk packaged ITNs.

The bale of ITNs

The ITN bale, containing a variable quantity of ITNs, can be considered to be a logistics unit. A logistics unit packages a number of trade items together for transport and/or storage and subsequent management as a single entity throughout the supply chain. In other contexts this could be a shipping container, a pallet or a carton.

The GS1 AI-conveyed data recommended by TraceNet for inclusion on a bale of ITNs are:

- (00) Serial Shipping Container Code (SSCC) - Each logistics unit (bale of ITNs) is assigned a unique SSCC, ensuring that it can be tracked individually throughout the supply chain without confusion with any other logistics units.
- (37) Count number - The quantity of trade items contained inside the logistics unit (the bale). In the example here the logistics unit (the bale) contains 50 individual ITNs.
- (02) The GS1 Application Identifier is used to identify the GTIN® of items contained within a bale of ITNs. (02) is used in conjunction with AI (37), which indicates the quantity of those items within the logistics unit.
- (11) Production date
- (10) Batch/lot

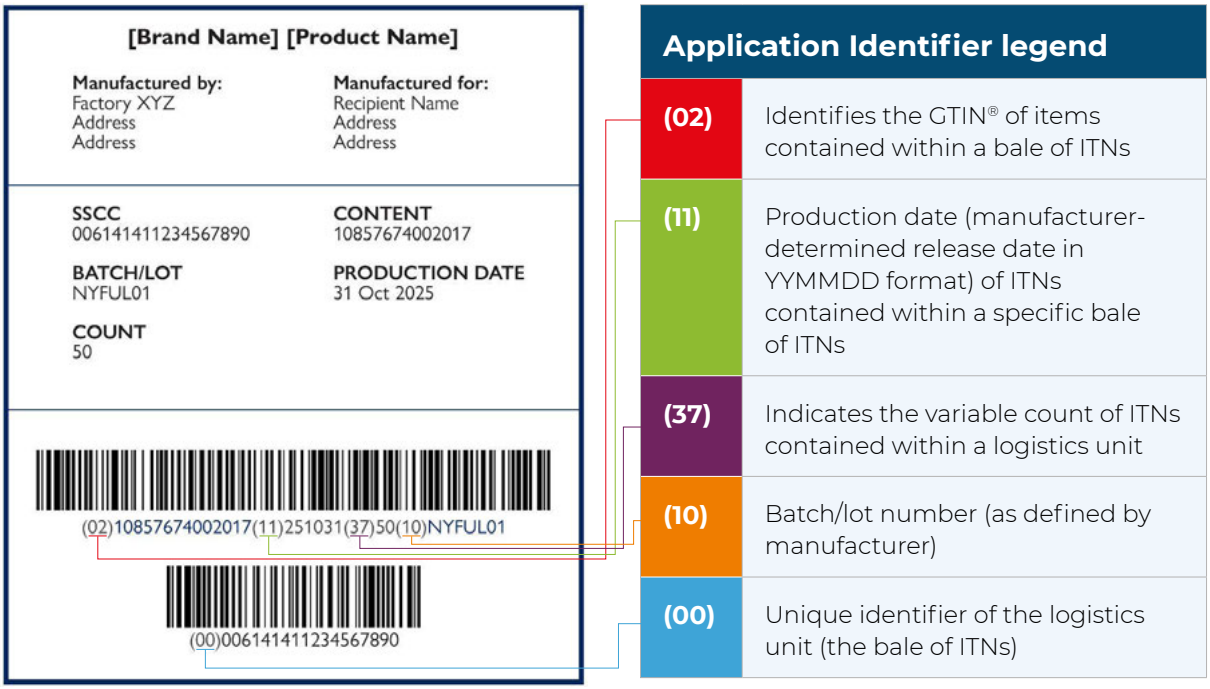


Bale of ITNs

The TraceNet-recommended data carrier to convey this information is the GS1-128 linear barcode.

Note that in Figure 3 there are two data carriers, both of which are GS1-128 linear barcodes. This reflects the fundamental difference between the GTIN® identifying the trade item and the SSCC identifying which specific logistics unit is containing the trade item.

Figure 3: *Label on an ITN bale*



Note about the data carriers

Though both are sometimes referred to as 2D barcodes, GS1 2D DataMatrix codes are not QR codes and should not be referred to as such. DataMatrix codes are a type of two-dimensional barcode, but they are smaller and more compact than QR codes. QR codes are more commonly used for website/URL redirection purposes. The term "barcode" is commonly used to refer to both the traditional **1D (linear)** codes (like Universal Product Codes (UPCs), which use lines and spaces) and the newer **2D** codes (like Data Matrix and QR codes, which use patterns of dots or squares).

GS1-128 linear barcodes are used in industrial settings, such as manufacturing and logistics, because the linear structure of the data carrier is well-suited for the types of laser and image scanners commonly used in logistics settings. This is principally why they have been recommended by TraceNet for use with the labels on bales of ITNs.

The creation of a record of the individual ITN serial numbers associated to the unique SSCC of the bale within which they are packed is technically possible though not a minimum recommendation of TraceNet. This is because, as of early 2025, doing so has been identified by manufacturers as operationally challenging as it moves beyond simply identifying individual ITNs with a serial number, to building and maintaining a dynamic, multi-level relationship, across an entire supply chain, of the unique ITNs and the unique bales with which they are associated.

5. DATA CAPTURE OF ITN LABEL CONTENT

Scanning is a physical interaction with a data carrier to acquire the encoded information. This is known as data capture. Once the alphanumeric string of data conveyed on a data carrier has been captured by a scanning device, this string of data is sent to the digital device where it will be stored.

Using the example in figure 3 from the ITN bale data carrier:

Application Identifier legend	
(02)	Identifies the GTIN® of items contained within a bale of ITNs
(11)	Production date (manufacturer-determined release date in YYMMDD format) of ITNs contained within a specific bale of ITNs
(37)	Indicates the variable count of ITNs contained within a logistics unit
(10)	Batch/lot number (as defined by manufacturer)

The data carrier is set up to both deliver the alphanumeric data string upon scanning and to use Application Identifiers to tell the scanner which part of the string corresponds to which type of data. For example:

- When the barcode above is scanned, the "NYFUL01" sequence after the (10) in parenthesis (note that all the parentheses in the example are there only to support human reading), can be identified as the batch/lot number because the 10 is the GS1 defined Application Identifier for batch/lot.
- The "251031" that is preceded by (11) can be identified when scanned as the production date.

Scanner

Data capture of TraceNet-recommended labels requires a data carrier, scanning hardware, an operating system for the scanner and a system to store/process the data. Any hardware product used for scanning will require some configuration to ensure it is set up to support scanning of standardized data carriers. A suitably configured scanner will be able to record the alphanumeric string of characters conveyed on each data carrier. The operating system of the scanner should be configured to be able to parse the scanned data by the type of data per the Application Identifier encoded in each data carrier.

In selecting the device that will be used to scan ITN data carriers there are several considerations:

- Scanner type: an appropriate type of scanner based on the operational environment (warehousing, transport, facility, temporary site) and ancillary scanning needs (recharging, network connectivity) should be chosen. The expected duration and frequency of use should be considered when looking at ergonomic design aspects of the scanner device.
- Durability: devices appropriate for environments that may expose equipment to harsh conditions should be selected.
- Connectivity options: scanners must support various connectivity options (e.g. off-line working modes, wi-fi, seamless integration with other devices or platforms).

Scanner operating system

The scanner and the scanner operating system should:

- Support multiple data carrier formats: GS1 2D DataMatrix, GS1 128 linear.
- Perform data validation: validation checks should be incorporated to ensure scanned data meet predetermined criteria, reducing errors.
- Have an intuitive design: the interface should be user-friendly and easy to navigate, minimizing the learning curve for new users.
- Have feedback mechanisms: the interface design should provide immediate feedback like sounds or visual confirmations when a scan is successful or if there is an error.
- Have clear visuals: there should be clear use of icons, labels and visual cues to guide users through the scanning process.

Scanner

Using mobile phones for data capture

While mobile phones do provide some technical advantages over built-for-purpose scanners and offer a convenient path towards the incorporation of AIDC into ITN supply chain programming, there are a number of challenges with using them that should be considered. Table 3 gives examples of what should be taken into account.

Mobile phone with GS1 DataMatrix application

Table 3: *Challenges of using a smartphone for scanning*

Potential challenge
While some smartphones can scan GS1 DataMatrix codes, others may require brand-specific applications to be installed. The wide variety of smartphone operating systems and versions of those operating systems and hardware can also lead to inconsistencies in application performance and subsequent need for extensive testing to be built into campaign plans and timelines.
Intensive use of AIDC applications can quickly drain smartphone batteries, requiring frequent recharging or external power solutions, which can disrupt workflows and potentially interrupt data capture.
Unlike devices specifically designed for AIDC, consumer-grade mobile phones are generally not designed to withstand harsh working environments such as extreme temperatures. This can lead to device damage or reduced device lifespan.
Holding and operating a smartphone for extended periods of scanning or data entry can be less ergonomic than purpose-built AIDC devices, potentially leading to user fatigue or demotivation. Smaller screens and virtual keyboards on mobile phones can limit data visibility and make data entry cumbersome for certain AIDC applications. While AIDC aims to reduce human error, any manual data input on mobile phones, even with touch screens, can still be error-prone.
While modern smartphones have good cameras, they may not offer the same scanning speed or range as dedicated barcode scanners especially in challenging lighting conditions. The quality of a mobile phone's camera can result in misinterpretations of patterns in a 2D DataMatrix data carrier code and possibly misreads of the data conveyed.

6. ITN PROGRAMMING INFORMATION MANAGEMENT PLATFORM DESIGN CONSIDERATIONS

Quality assurance and validation

- Regular audits and automated checks should be built into the platform design and should be conducted to minimize errors and ensure data integrity.
- Methods to verify the uniqueness of scanned data carriers should be implemented, preventing duplication within the system.
- Design should incorporate alerts where duplicate data carrier elements should not occur and provide user prompts for follow-up actions.

Alignment of data structures

Even when data are being conveyed on the data carriers on ITN labels, the recording of the data in the record system should be configured to examine the totality of the complete alphanumeric string. The scan must parse the alphanumeric string by Application Identifiers, capture the associated data and record them in the record system according to the format intended to be conveyed. Date formatting is a critical aspect of this configuration.

For example, using the previous example from the ITN bale data carrier:

Application Identifier legend	
(02)	Identifies the GTIN® of items contained within a bale of ITNs
(11)	Production date (manufacturer-determined release date in YYMMDD format) of ITNs contained within a specific bale of ITNs
(37)	Indicates the variable count of ITNs contained within a logistics unit
(10)	Batch/lot number (as defined by manufacturer)

The numeric string that follows the (11) in the example above is the production date. The GS1 standard date format is YYMMDD, which represents the year, month and day using two digits each. The numeric string from the example should only be conveyed, captured and interpreted as 31 October 2025 and should only be interpreted as the production date.

If ITN programming is relying on AIDC but the platform used to record the data from the scan has a date format other than the GS1 date standard, is not configured to record production date, or is configured incorrectly to interpret the date as something other than production date, then missed data, incorrect data or the need to manually enter data may result. An issue that could also arise is when an ITN-specific software application is designed to require the user to manually input data that are readily available via AIDC, needlessly adding effort and the likelihood of error.

Product description management

Ensure the primary output from data capture is compatible with the inventory management modules of ITN programming platforms or other inventory management systems, ideally including those of the manufacturers and suppliers. Arriving at this compatibility requires stakeholders to appreciate the importance of a standardized product description and the need to avoid having different systems describing exactly the same product in a different way.

While a GTIN® itself is not a product description, it can serve as the primary key to the product description as all relevant product attributes are associated with it, specifically what the product is named. As the manufacturer and the buyer can use the same GTIN®-based product name/description for a unique shipment of ITNs, there is benefit to using the same, rather than a different name/description for the same ITNs when they are managed in-country as it will greatly facilitate communications, inquiries and follow-up.

On the other hand, not using the GTIN®-based description and instead, using a generic product description for any and all ITNs, will complicate communications, inquiries and follow-up because characteristics such as brand, size, insecticide type may vary over time, sometimes even over the course of a single year or even month when ITNs from different manufacturers are being managed.

Data security

Robust security measures should be incorporated within the ITN information management platform to protect sensitive data, including user authentication. Scanned data should be stored long term in a centralized database with controlled access to ensure that only authorized personnel can view sensitive information during and after the ITN distribution.

Integration of AIDC-derived data across digital tools

Successful integration is not so much dependent on the data carrier itself but rather the systems that capture and share the data conveyed in the data carrier and generate event data. If one system is expecting to capture data on a specific ITN attribute or receive the record of that same attribute from another system, and the attribute has never been conveyed on the data carrier or has not been captured, then there can be no integration of that attribute.

A worse situation would be where systems are integrated but one or more systems imprecisely translate the captured data. This could occur in an example where date formatting is different or there is reliance on a product description other than that used elsewhere in the supply chain. Date formatting inconsistencies, such as those described previously, do not prevent integrated systems sharing the data but will result in incongruous data and possible inventory issues such as incorrect management of shelf-life.

7. APPLYING AIDC TO THE ITN SUPPLY CHAIN (where, when and how)

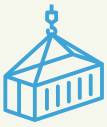
With three AIDC enablers in place - (1) ITNs and bales labelled with data carriers, (2) scanning hardware, and (3) operational information management system(s) - a defined operational process is required to realize the benefits of AIDC.

Regardless of how a supply chain process is labelled or described, or where within the supply chain an event occurs, there are AIDC events that all three types of ITN data carriers encounter. These are instances within the supply chain, specific more to a data-related event than where the physical handling of an ITN product occurs. The commonality of these events can assist users in understanding where and when AIDC for the ITN supply chain can be and should be used.

Table 4: *shows examples of data-related events*

Event	Instance
Aggregation	Instances of when individual bales or individual ITNs are combined into a larger container as when individual bales are loaded into a container or vehicle or individual ITNs are packed into a bale.
Disaggregation	Instances of when there is a separation of units that were previously combined, as when a container of bales is unloaded or when ITNs within a bale are removed.
Decommissioning	The point at which a serialized ITN unit leaves the controlled, traceable supply chain. The act of decommissioning a serial number serves to prevent that same serialized package, or another package with the same serial number, from being re-entered into the supply chain (e.g. as a counterfeit or diverted product).
Observation	Any recording of an ITN unit (bale or individual ITN) instance that does not change its status or fit into the other event types (e.g. an inspection or scan of a product without altering it). This observation could be adjacent or separate to any other supply chain related process.

Table 5: *provides examples of where these data-related events can occur within an ITN supply chain*

AIDC events					
Manufacturer	Commissioning				
	Packing of individual ITNs into bales				
Procurer		Aggregation			
		Bales loaded into freight containers			
Receiver			Disaggregation		
			Bales unloaded from freight containers		
Distributor				Aggregation	
				Bales loaded into trucks	
Distribution point					Disaggregation
					 Bales unloaded from trucks
					Decommissionning
					ITNs removed from bales
					Aggregation
					Reverse logistics

To support the availability of end-to-end supply chain visibility AIDC should ideally occur at multiple points in the supply chain, including:

- Receipt from manufacturer/supplier at the procurement defined destination
- Regional and district warehouses
- Pre-positioning points and distribution sites

The benefits of scanning at each level are as follows:

- Central level: ensures accurate inventory upon receipt
- Regional and district warehouses: facilitates real-time tracking of stock levels
- Pre-positioning points: enhances accountability before distribution
- Distribution points: confirms delivery (departure from the supply chain) and reduces discrepancies

Event data

The “instances” illustrated above are not just timebound. As well as time of the occurrence, they are bound to their place of occurrence and the purpose of their occurrence. Combining master data and transactional data with time, place and purpose creates event data.

When event data are created ITN distribution stakeholders can essentially answer the fundamental questions for each significant supply chain process that a ITN may encounter, i.e.

- What item was involved?
- Who was involved?
- Where did the event happen?
- When did it happen?
- Why did it happen?

8. OBSERVATION OF ITNS ON RECEIPT AT THE COUNTRY LEVEL

As a companion to any pre-shipment quality assurance inspection of individual ITNs there should also be an in-country inspection, principally conducted visually, of a sample of the labels on bales, individual bags and individual ITNs to provide a basis for quality control and to ensure that subsequently planned AIDC-based processes will be possible. Inspection can accomplish the following:

- Identify non-scannable labels
- Identify labels that may scan but convey incorrect data
- Verify human readability of label contents
- Support the audit trail by providing a point of verification that labels meet expectations before further action

Inspection of labels is described in Table 6.

Table 6: *Label inspection*

To be inspected	Component	Detail
Legibility and print quality	Clarity	No smudging, fading or blurring of the text, numbers and data carriers.
	Contrast	There is sufficient contrast between the print and the label background for barcode scanner readability.
	Distortion	Data carriers are free from wrinkles or other distortions that might hinder successful scanning.
	Darkness/density	The printing is dark enough to be easily scanned and read by humans.
	Overlapping	Labels are placed such that they do not overlap other critical labels or important package information.
Accuracy of information	Correct data	Information on the label (e.g. GTIN®, product description, quantity, lot/batch number, expiration date, serial number) match the actual contents of the package and accompanying documentation.
	Format and layout	The label adheres to specified labelling requirements. The required quantity of labels is present in the required size.
	Required elements	The label includes all mandatory information and is presented in the language required of the customer.
Label integrity and adherence	Appropriate placement	Labels are applied to flat, scannable surfaces and not wrapped around corners, over edges or on seams.
	Secure adhesion	Labels are firmly fixed with no sign they will easily detach during transit.
	Damage/wear	Labels are free from creases, punctures, water damage, dirt or abrasions that could hinder AIDC.

9. RESOLVING OBSERVED ITN LABELLING DISCREPANCIES

The degree to which any observed discrepancy will be resolved will depend on the scale of the discrepancy within the sampled quantities and the degree to which any subsequently planned AIDC-based processes will be impacted by the discrepancy. For example if only one bale out of a container of 400 bales was observed with all the labels damaged and, as a result, unscannable, receivers could be instructed to follow procedures for printing replacement labels using the human readable content conveyed on the label. If, on the other hand none of the sampled 400 bales had scannable data carriers the receiving organization should likely raise a concern that is escalated to the attention of the funder, procurer, freight forwarder and manufacturer.

When replacing a damaged label, it is critical that the new label contains the identical, correct data as the original, especially the mandatory unique identifiers like the SSCC for logistic labels. Users should be re-printing the label and avoiding generating a new, unique identifier that was not used on the original logistic unit.

The replacement label must adhere to all GS1 printing guidelines, including minimum print quality, proper colour contrast (dark bars on a light background), correct quiet zones, and appropriate size to ensure it is readable by scanners.

In summary, logistics staff should have the capability to replace a damaged label to avoid delays and errors, and the process should be integrated into a system to ensure the reprint is a perfect, high-quality copy of the original data.

10. IN-COUNTRY DISAGGREGATION AND AGGREGATION OF BALES OF ITNS

The first disaggregation at a country level (whether central, regional or district) is also often the largest volume disaggregation as it is the instance where the largest number of containers, each containing multiple ITN bales, will be unloaded at a single destination. Getting a correct record of what is received during the initial delivery in-country is critical. Simply recording the count of the number of bales received is inadequate.

Receiving best practice dictates that goods should always be received against a document that details what is expected to be received. This document (electronic or paper based) could be something akin to a purchase order, packing list, advanced shipping notice, or invoice. For this best practice to be implemented, the record of what was shipped must be available prior to receiving and in a format to be used in conjunction with AIDC. Following this best practice allows for:

- Verification: what is received matches what was ordered or what the supplier indicated they were shipping.
- Accuracy: discrepancies can be prevented such as receiving the wrong quantities, wrong items, or items that were not ordered.
- Accountability: provides a record to be used for resolving subsequent issues such as inventory discrepancies.

Using the SSCC on ITN bales during disaggregation

Where accountability is required until ITN decommissioning, then activities that result in a determination that the quantities received match the quantities reported as shipped is insufficient.

The first disaggregation instance should confirm that every SSCC is scanned, that every scanned SSCC matches a record of a SSCC said to have been shipped and that the aggregate of the count of the matching records is equal to the quantity documented as shipped.

Disaggregation using only the SSCC

Figure 4: *SSCC*

It has been shown earlier in this guidance that the sequence of numbers after the (00) in Figure 4 above is the SSCC and that each logistics unit (bale of ITNs) is assigned a unique SSCC to ensure that it can be tracked individually throughout the supply chain. When the ITN supply chain management software is configured to be able to disaggregate against a populated record of the shipment provided in advance by the manufacturer or supplier, only the SSCC needs to be scanned. This is because the SSCC is designed to enable the inventory management software to link the SSCC with the record which identifies the contents of a single bale. This can only happen if the information management system is populated with a record provided in advance by the manufacturer or supplier containing:

- The SSCC of each bale
- The contents of each unique SSCC, including the GTIN®s, quantities, batch/lot numbers, and production date. The contents of each logistics unit may vary, as batch/lot numbers, unit count and product dates change during the manufacturing process.

Configuring the inventory management system or the inventory management module of an information management system in advance and pre-populating this system with the shipment-related data provided by the manufacturer/supplier requires more upfront effort than not doing so. An argument could also be made that not including AIDC during the initial unloading of containers could be faster than it would be if each SSCC is scanned during container unloading. However, these justifications conflict with accountability requirements. For example, if AIDC is planned to be incorporated into the receiving process after containers are unloaded, there is likely more effort required and greater likelihood that there will be a challenge encountered with reconciling overall quantities or quantities of bales per unique container.

Manual SSCC disaggregation

If there is a shipping record available but it has not been populated or cannot be populated into the inventory management software platform in advance of receiving, the inventory management system should be configured to prompt a user to scan once to capture the SSCC and scan a second time to capture the second data carrier containing the GTIN® and other AIs unless a scanner with multi-code reading technology is being used. As previously detailed in this guidance, the inventory management software should be configured to parse all of the AIs and automatically convey the related data to the record of what was

received. If the inventory management software requires users to scan both data carriers on the label of the bale and then subsequently requires the user to enter quantities and other attributes such as production date and batch/lot number, this effectively negates the efficiency benefits of using an SSCC for receiving. The SSCC will still function as a unique identifier for each bale in this case, allowing its movement to be tracked, but its contents must be continually tracked separately.

Receiving with partial disaggregation

The first disaggregation is a critical event in the ITN supply chain because it marks a change in physical handling of the goods and because it may also be the moment at which there is change in custodial responsibility of ITNs from the manufacturer/supplier to the in-country stakeholder receiving the shipment.

When disaggregation is an element of the receiving process, there is a transition from tracking a larger unit (a container said to contain a certain quantity of bales) to tracking its smaller components (identified by their individual GTIN®s and other attributes). Without any disaggregation incorporated into the receiving process the following two records are produced, related but insufficiently linked:

- A record of an unloaded container documented as containing a set number of bales
- A companion record of a quantity of bales or a quantity of ITNs having been entered into inventory

This will compromise the ITN supply chain management's function to manage and track ITNs end-to-end and will potentially expose the programme to widespread negative consequences regarding lack of accountability. To minimize this risk, ITN programming should incorporate, as a minimum step, a sampling of disaggregation to establish, if not 100 per cent certainty in the reconciling of quantities received against the record of quantities shipped, a degree of certainty of this. This sampling could be incorporated into the inspection/observation event or included during a subsequent aggregation event.

With sampling, receivers would not scan every single bale at the first transfer into the custody of the NMP. Rather they could use a sampling methodology whereby a percentage of the total number of containers would be received with every SSCC recorded and where the unique bales are received against the packing list that details the unique bales per containers included in the sample. Additionally, any container for which the absolute physical count did not match the packing list count would have each bale scanned to determine which unique bale(s) are missing or are not included in the packing list.

Reconciling ITN bale disaggregation discrepancies

When the quantities of ITN bales counted do not reconcile with the quantity of bales expected during a disaggregation event there may have been a breakdown in inventory accuracy and traceability that needs to be addressed. Similarly, when the physical count of ITN bales is correct, but the record of SSCCs on the inbound shipping document does not match the SSCCs scanned, it indicates a data integrity issue, or even a material management-linked issue, rather than a quantity issue. For instance there could be duplicate SSCC. There is also the possibility that bales for different customers have been mixed up at the manufacturer with the result that the count is correct but the SSCCs do not match.

As SSCCs are the backbone of ITN supply chain traceability, SSCC mismatches should evoke a serious response as quantity or item discrepancies can have negative effects on subsequent ITN supply chain programming, particularly in a digitalization-enabled ITN supply chain.

The following actions, detailed in Table 7 below, taken at the point of a discrepancy being detected, can assist in immediately resolving quantity discrepancies or SSCC mismatches and can also provide logistics management with valuable insights towards improving overall inventory management processes, enhancing traceability and minimizing future errors.

The processing of a shipment with a discrepancy should be paused and action taken as in Table 7. Discrepant SSCCs should not be accepted, nor quantities marked as valid in the supply chain information system nor items put away until the discrepancy is resolved.

Table 7: *Steps to resolve a discrepancy*

Overall step		Detail
VERIFY THE COUNT (SSCC)		▪ Re-count physically. Re-count the ITN bales that were supposed to be disaggregated from the vehicle that delivers them. ▪ Re-scan discrepant SSCCs. Ensure good scan quality. ▪ Manual verification. If scanning is problematic, manually verify the human-readable portions of the SSCCs on the ITN bales. ▪ Record the discrepancy. Note down the details of which SSCCs are missing from the physical shipment, and which unexpected SSCCs are present. ▪ Record the date, time and the individuals involved.
INVESTIGATE THE ROOT CAUSE	**Internal process errors**	▪ Receiving procedures. Were receiving personnel following correct procedures? Was there a step skipped or misunderstood? ▪ Miscounts. Was the initial count during disaggregation incorrect? ▪ Mis-scans. Was the data carrier mis-scanned or not scanned at all? ▪ Incorrect data entry. Were data manually entered incorrectly at any point during the disaggregation?
	System issues	▪ Hardware malfunction. Are data carrier scanners working correctly? Are there issues with reading certain data carriers? ▪ Software glitches. Are there issues with the ITN supply chain software that cause data corruption and/or incorrect processing? ▪ SSCC matching. Does the ITN supply chain management system accurately match incoming SSCCs to the SSCCs documented on the shipping-related document? ▪ Integration problems. If shipping documentation is integrated electronically into the ITN supply chain management software, is there an issue with the data transfer from the supplier's system?
	External factors. If documentation is available from the aggregation event that created the shipment, review that documentation	▪ Did the supplier/shipper short-ship, over-ship or pack incorrect items into the aggregated unit? ▪ Did the supplier/shipper substitute SSCCs? Were there last-minute changes not reflected in the shipping documentation? ▪ Was an ITN bale label missing its data carrier, preventing it from being scanned? ▪ If the total count is correct, is it possible specific SSCC-identified units were lost and replaced with other ITN bales?
	Determine what the accurate record is	▪ Supplier confirmation. If the supplier/shipper confirms which SSCCs were actually shipped and their records match the physical record of what has been disaggregated, then the record of the expected quantity to be received was likely incorrect. ▪ Override data. If the supplier/shipper cannot provide clear documentation or explanations and the SSCCs have been thoroughly re-verified, the physical data capture record can become the authoritative record.
	Adjust the ITN supply chain management system records	▪ Remove SSCCs that were on the original shipping-related documentation but not received or add SSCCs that were received but were not on the original shipping-related documentation. ▪ Document the SSCC or count discrepancy, the root cause and the corrective action taken to create an audit trail and provide the baseline data for future process improvement. ▪ Make the necessary adjustments to the ITN supply chain software system to reflect the actual physical count of the disaggregated items.
	Follow up	▪ Inform purchasing/procurement counterparts to ensure they are aware of the discrepancy, especially if it points to a recurring issue with a specific supplier or shipper. ▪ Inform accounting or contract management personnel so they can make any necessary adjustments to inventory valuation or vendor payments. ▪ If the issue originated with the manufacturer, supplier or transporter, provide a record of expected vs. received SSCCs or expected vs. received quantities to the supplier/shipper and initiate a claim or dispute resolution process.
PREVENTIVE MEASURES	**Process review and training**	▪ Review and update SOPs for receiving, aggregation and disaggregation. ▪ Regularly train and retrain staff on proper data capture techniques, counting methods and discrepancy recording procedures. ▪ Consider implementing a two-person verification step during critical ITN disaggregation events.
	Technology	▪ Ensure scanners are working properly. ▪ Leverage supply chain software features that aid in reconciliation, such as real-time validation, alerts for discrepancies and robust reporting on inventory variances. ▪ Regularly audit data integrations between systems to ensure data flow accurately and completely.
	Supplier performance management	▪ Track supplier (both manufacturer and shipper) accuracy rates. ▪ Implement corrective action plans where there are frequent discrepancies. ▪ For problematic suppliers, consider pre-shipment inspections or third-party verification.

Aggregation events – bales of ITNs

The first aggregation of ITN bales at the country level should ideally be preceded by a disaggregation event as above. Aggregation facilitates the tracking and tracing of a single ITN bale from its point of origin through to subsequent locations at each level of the supply chain. During aggregation each bale of ITNs, each with a unique SSCC, is scanned and then combined with other unique ITN bales into a load, cargo or shipment for transfer to another site.

Aggregation best practice, whether this be called packing, picking or loading, dictates that goods should always be aggregated against a document that details what is expected to be eventually delivered to another location. This record (electronic or paper based) could be something akin to a purchase order or packing list. For this best practice to be implemented the record of what is to be shipped must be available prior to aggregation and in a format to be used in conjunction with AIDC.

Following this best practice allows for:

- Verification: what is aggregated matches what was ordered or what has been planned to allocate or distribute
- Accuracy: discrepancies can be prevented such as loading the incorrect quantities of ITNs
- Accountability: provides a record to be used for resolving subsequent issues such as inventory discrepancies

Subsequent disaggregation and aggregation events

Aggregation and disaggregation of ITN bales will occur numerous times during ITN supply chain programming, ultimately ending with their decommissioning as they are opened and the individual ITNs inside them are removed. The principles of the first in-country disaggregation and aggregation should apply to subsequent movements of ITNs through the supply chain. When there are discrepancies in the counts made during subsequent aggregation and disaggregation events, many of the same steps and actions indicated previously under the guidance for the first disaggregation can be followed.

If there has been neither a complete disaggregation upon receipt of an ITN shipment or subsequent aggregation events pertaining to the original quantity of ITN bales as they are dispersed to multiple distribution points, AIDC can still be incorporated. However, overall surety and confidence in the totality of the supply chain will be greatly diminished in the event questions arise regarding where ITNs went or how ITNs came to be at a particular location.

11. IN-COUNTRY DECOMMISSIONING

Decommissioning ITN bales

The point within the ITN supply chain where the SSCCs on bales of ITNs are decommissioned will depend on whether the ITNs are removed from them at once (full disaggregation, as is often the case in mass campaign and school-based distribution) or if they are removed one by one over a longer period of time (partial disaggregation, as is often the case for routine and community-based distribution). The SSCC's decommissioning is triggered by commencement of the unpacking process.

As of 2025 the decommissioning of SSCCs for most, if not all ITN bales, will be the first opportunity supply chain management has to begin accounting for, reconciling and tracking the unique serial numbers for each ITN. Linking a serialized item to the decommissioned SSCC from which it was unpacked is a crucial aspect of maintaining end-to-end traceability in a digitalized ITN supply chain. While the SSCC itself is decommissioned, the historical relationship between the SSCC and its content of individual ITNs must be preserved even after the SSCC is no longer an active logistics unit.

The use of AIDC during the ITN bale unpacking process will vary according to whether the digitalized system tracks the serial number of each unique ITN and whether ITNs are packed in bulk or in individual bags. If the system requires each ITN's unique serial number to be captured and subsequently tracked and the ITNs are packed in individual bags, the bags may need to be opened and the individual ITNs removed in order for the serial number to be captured via AIDC. As of early 2025, the main funders of ITNs did not require manufacturers to document an ITN's unique serial number association with the SSCC in which they were packed. For the same reason, for end-to-end ITN supply chain visibility it is recommended that the unique ITN serial numbers are captured when they are removed from an ITN bale for decommissioning. This step in the supply chain is the most logical place to create a record of which unique ITNs were in each unique ITN bale.

Full SSCC decommissioning

Full decommissioning of the SSCC for a bale of ITNs results in its purpose as an identifier for a logistics unit ending. It will also result in the inventory it contains shifting from the SSCC level to a lower inventory level. Decommissioning an SSCC impacts the traceability of logistics units but does not change the total physical count of the individual ITNs themselves. The inventory count for the individual ITN will only change if they are subsequently moved out of the total inventory and thus are decommissioned themselves.

Partial SSCC decommissioning

With partial decommissioning the SSCC can remain active but the original corresponding data conveyed regarding the quantity contained linked to the SSCC will no longer be valid. The ITN inventory management software system should be configured to have the associated inventory count of the SSCC reduced by the number of units disaggregated. The system would then still consider the SSCC to be a valid logistics unit containing the remaining quantity of ITNs until all ITNs have been removed.

Decommissioning individual ITNs

Similar to what is done with the decommissioning of the SSCCs of unique bales of ITNs, the decommissioning of an individual ITN is the point at which a serialized ITN unit leaves the controlled, traceable supply chain.

The design and incorporation of AIDC processes at this stage should facilitate end-to-end visibility of the ITN supply chain. End-to-end supply chain visibility is enabled when the record of which unique ITN was removed from which unique bale (based on the unique SSCC) has been previously produced and then subsequently linked to the event data associated with the time, place and authorized personnel where ITNs are decommissioned.

If SSCC decommissioning is occurring simultaneously with the distribution of ITNs to recipients, then best practice would be to configure the ITN programming software to be able to associate each ITN to the SSCC from which it originated. This could be done, for instance, by prompting the user to scan both the SSCC on the bale and the 2D matrix barcode on the individual ITN prior to handing the ITN to a recipient and thus decommissioning the ITN.

12. ITN TRACKING AND TRACING

While "tracking" and "tracing" are often used interchangeably they have distinct meanings and applications when used in the context of supply chain management. Tracking is forward looking and focuses on being able to determine the location and status of a unit or shipment of units as it moves through the supply chain. Tracing is backwards looking and focuses on reconstructing the history of a logistics unit through the supply chain (where something came from, what processes it underwent).

The extent to which either end-to-end tracking or end-to-end tracing can be accomplished is dependent on there being a record, or records, of any aggregation, disaggregation or decommissioning events that either preceded or followed a data-capture event. The following four scenarios illustrate this, the first two for ITN bales and the second two for individual ITNs.

ITN bales	
Scenario 1: The unique serial number of an ITN bale (the SSCC) is only captured via AIDC when the ITNs contained inside it are decommissioned in the process of being distributed to recipients.	**Scenario 1 outcome:** This is good practice in that there is a record created of the decommissioning of each ITN and a recording of the relationship between the individual ITN, the unique bale from which it was disaggregated and the time and place this occurs. ITN distribution that follows this procedure will be able to have a record of all the individual bales decommissioned and unique, individual, ITNs distributed. If, however, the total quantity of individual ITNs distributed does not equal the total quantity of ITNs initially received from the manufacturer/procurer, addressing this discrepancy quickly and thoroughly will be challenging and perhaps impossible.
Scenario 2: Only the data carriers on bales of ITNs are scanned and not the data carriers on individual ITNs. However, the data carriers on bales of ITNs are scanned every time they are involved in a disaggregation, aggregation or decommissioning event that occurs through the entire in-country supply chain.	**Scenario 2 outcome:** With this scenario a record is produced of where every bale (that details both the quantity of individual ITNs in the bale and the batch/lot of that quantity of ITNs) is encountered through the supply chain. The ITN bale decommissioning event occurring at a distribution point produces event data recording that at such a time and place an authorized person emptied a unique bale of ITNs containing a specified number of individual ITNs. Which unique ITNs were decommissioned is not recorded.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Comparing the two scenarios

If everything goes right in scenario one, an NMP would be able to confirm that the total number of unique ITNs procured exactly matches the total quantity of unique ITNs that were distributed. In the second scenario, although there is no record of the unique ITNs distributed, there is still a record of the number of unique ITNs decommissioned from bales. If the total number of unique ITNs procured does not match the total quantity of unique ITNs that were distributed, there is a record for when each bale of ITNs received was either disaggregated, aggregated or decommissioned from which the reconciling of quantities can be initiated.

Either scenario will create records of the quantities of ITNs distributed and complementary records of the quantity of unique ITN bales decommissioned. But in scenario two, unlike the first scenario, if the total quantity of individual ITNs distributed does not equal the total quantity of ITNs initially received from the manufacturer/procurer, logistics staff should be able to determine, in the case of the discrepancy being a shortage, which unique bale or bales of ITNs had not been recorded as being decommissioned and determine where that non-decommissioned bale had last been disaggregated.

Individual ITNs

Tracking and tracing aspects are further elaborated in the following scenarios where:

- A single ITN is encountered somewhere it would not be expected to be
- A label is affixed to the ITN that includes a unique serial number

Querying the in-country history of the individual serialized ITN, the end-to-end ITN supply chain data, if they exist, could indicate the following (in reverse order):

Individual ITNs	
Scenario 3: ▪ It was decommissioned at distribution point "Z", by person "Y" on date "X" and was provided to household "W" ▪ It was disaggregated from the bale of ITNs with the SSCC "W" at distribution point "Z", by person "Y" on date "X" ▪ The ITN bale with SSCC "W" disaggregated from a vehicle and was received at the distribution point "Z" by person "Y" on date "V" ▪ The ITN bale with SSCC "W" was aggregated during loading into a vehicle at distribution point "T" by person "S" on date "R" ▪ The ITN bale with SSCC "W" was disaggregated from a shipping container received at distribution point "T" by person "Q" on date "P"	**Scenario 3 outcome:** As there is a record of the decommissioning of the ITN from the time it left the supply chain and the complete history of the ITN prior to its decommissioning is available, ITN programming stakeholders can be assured that the ITN was managed with full accountability through the ITN supply chain. Interest should then principally revolve around how it got from the last place where it was decommissioned to where it has been encountered.
Scenario 4: There is a record of the ITN having been part of the total shipment (via the transaction data produced by the manufacturer)) but there are no event data captured specific to that individual ITN's serial number either being removed from a ITN bale during a disaggregation event or during a decommissioning event linked to the unique ITN.	**Scenario 4 outcome** If, similar to Scenario 3, an individual ITN's serial number is normally recorded when it leaves the supply chain but there is no record of this having been done for the encountered ITN, the lot/batch number should be examined. With the lot/batch number in hand it is possible, assuming all bales have been scanned at some point, to determine where bales containing that lot number were distributed. A user may then be unable to determine which bale it came from with certainty, but being able to report with certainty that the ITN came from a unique subset of bales for which there are event data regarding where and when they moved through the supply chain could be an adequate point from which to proceed with further investigation.

Standard Operating Procedures (SOPs) to support tracking and tracing

The ability for ITN programming to have track and trace capabilities relies in part on the existence and use of SOPs specific to the AIDC-reliant processes that are used with ITN supply chains. SOPs should be developed and used under a robust quality management system that serves the NMP as a foundation for quality, consistency and compliance. This technical guidance is accompanied by several generic SOPs that are oriented towards key disaggregation, aggregation and decommissioning events that ITN programming is likely to encounter. These SOPs can be easily modified or adapted to fit the country and supply chain context. See: *Standard Operating Procedures - AIDC for ITN programming*.

13. REQUIREMENTS FOR INCORPORATING AIDC THROUGHOUT THE ITN SUPPLY CHAIN

Early ITN digitalization efforts primarily focused on improving data collection timeliness and accuracy for household registration and net distribution. Other complementary efforts, such as the TraceNet initiative, focused on reaching consensus among stakeholders on label format and content. As of early 2021, labels with data carriers have been delivered to countries and NMPs have been scanning and capturing some of the content on those labels. However, enabling and incorporating AIDC in an end-to-end ITN supply chain is a relatively new concept to all ITN distribution stakeholders, including manufacturers, suppliers, transporters and NMP staff. This level of incorporation of AIDC requires new interactions between procurement and supply chain staff, presenting some increase in the complexity of materials management, giving rise to new requirements and exposing ITN programming to the challenges detailed in Table 8.

Table 8: *Challenges with incorporating AIDC*

Requirement	Rationale
Funding and initial costs	The upfront investment in AIDC hardware (scanners, printers), software plus the costs of training, can be constraining in settings with limited financial resources. For training, alternatives such as e-learning options and virtual/online feedback mechanisms should be considered from the outset.
Funding ongoing costs	Ensuring the long-term sustainability of AIDC systems requires not only financial resources for software maintenance, upkeep and repairs, but also a continuous supply of necessary consumables like replacement barcode labels.
Functional utility of the infrastructure	Reliable electricity is crucial for most AIDC devices. In areas with frequent power outages or no access to a stable power supply, the incorporation of AIDC processes can be constrained. Similarly, poor internet connectivity can hinder data transmission and diminish the opportunity to reap the benefits of real-time tracking.
Equipment availability and reliability	Not all personnel may have access to the necessary scanning devices, which can create inconsistencies in data collection. Hardware malfunctions can disrupt the scanning process, leading to delays in tracking and inventory management.
Integration and interoperability	Developing robust and efficient AIDC applications for mobile phones requires specialized skills and can be very complex, especially when integrating with other existing inventory management software.

Requirement	Rationale
Technical expertise	Implementing AIDC systems requires appropriate levels of technical skills with the necessary expertise for set-up, troubleshooting, system management and training. Recruiting and training qualified staff for this can be time-consuming and costly.
User acceptance and digital device literacy	If end-users are not involved in the design and implementation process, or if the technologies are not user-friendly, there may be resistance to adoption leading to poor implementation and utilization of the scanning system.
Training	Insufficient training of users results in incorrect use of scanning technology or failure to follow protocols. Additionally, lower levels of digital device literacy can make the use of some AIDC systems (even seemingly simple barcode scanners) more challenging without adequate training and support. Combining this with manual processes that accompany AIDC increases the likelihood of data entry mistakes which can lead to significant discrepancies and inaccuracies.
Environmental resilience	AIDC technologies can be affected by harsh environmental conditions common in outdoor settings, such as high humidity, dust or heat. This can lead to unreadable, defaced or damaged barcodes or equipment failure, undermining the system's effectiveness.
Data security and privacy	While AIDC itself focuses on identification and data capture, the systems that manage the collected data need robust security measures. In settings where data protection regulations and infrastructure are weak, there is a risk of data breaches and misuse of sensitive information such as household or recipient data.
Access control and authentication	Managing user authorization to create, manage and process ITN supply chain data requires rigorous oversight of a network of stakeholders and organizations.
Data backup	Inadequate data backup protocols may result in loss of critical information due to system failures or cyberattacks.
Data sharing	AIDC-derived data, if decentralized and stored across multiple ITN stakeholders, can result in key data being fragmented or being inaccessible to authorized stakeholders.
Standardization and interoperability	Lack of standardized systems and data formats can create challenges when trying to integrate AIDC data with existing health information systems or across different organizations.

Requirement	Rationale
Integration with Electronic Logistic Management Information Systems (eLMIS)	Inconsistencies in how commodities are identified throughout the supply chain – from manufacturer, freight forwarders, medical stores and other supply chain points – often result in duplicative, incomplete and inaccurate data. This limits data visibility as an ITN unit moves through the supply chain and hinders integration, interoperability and electronic data exchange across varying eLMIS. This poses supply chain security risks as ITNs are inconsistently identified as they change custody from stakeholder to stakeholder. Additionally, failure to integrate ITN tracking with national health logistics systems and inconsistent coordination between ITN stakeholders regarding inventory tracking approaches and processes leads to inefficiencies and possibly errors.

CONCLUSION

At the beginning of this guidance, and in view of increased requirements for visibility and accountability in the supply chain due to constrained resources, the following questions were posed that NMPs increasingly need to be prepared to answer:

- Did all the ITNs said to have been shipped by the manufacturer/supplier arrive?
- Did all the bales of ITNs transported to pre-positioning or distribution sites arrive where they were supposed to go?
- Where was a specific bale of ITNs before it arrived at a specified location?
- Where and when did the ITNs get distributed and by whom were they distributed?

This planning and operational guidance on planning the use of barcode scanning for the ITN supply chain at country level illustrates how incorporating aspects of AIDC can lead to:

- Improved efficiency and productivity
- Enhanced accuracy and reduced errors
- Better inventory management
- Increased supply chain visibility
- Improved accountability, compliance and traceability

The benefits do, however, come with initial and ongoing costs such as investment in AIDC hardware (scanners, printers), software and training, maintenance, repairs and consumables (such as replacement barcode labels). Although investments of this nature may not be considered to be top priority in settings with limited financial resources, investing in end-to-end supply chain visibility through the incorporation of AIDC yields a strong Return on Investment (ROI) by systematically eliminating errors, reducing level of effort and improving the speed and accuracy of operations, leading to significant operational benefits.

It should be noted that, although a NMP may choose to include or exclude AIDC processes during select ITN supply chain events, the degree to which any one AIDC event can return the accountability and efficiency that is expected overall is limited by the degree to which AIDC has been incorporated into previous supply chain events.

Key returns include:

- Inventory accuracy: The strong ROI from AIDC is the result of shifting from an error-prone, labour-intensive system to a highly accurate, automated one.
- Reduction in data entry errors: automatic capture virtually eliminates typos and human keying mistakes that lead to inventory and shipping errors.
- Near real-time visibility: instant updates on inventory location and status allow for better planning, fewer inventory losses and a more responsive supply chain.
- Efficiency gains: faster identification and resolution of disruptions lead to improved ITN supply chain performance and reduced level of effort spent tracking shipments.

Incorporating AIDC into ITN supply chains, beyond the purpose of meeting supply chain accountability, opens the door for ITN stakeholders to utilize AIDC-enabled ITN labels and the resulting data for a variety of other purposes. For example:

- ITN verification during household level surveys
- Durability monitoring
- Quality assurance processes, reviews and analysis
- Evaluating distribution effectiveness
- Informing future procurement based on supplier performance
- Product authentication for purposes of product diversion detection
- Seamless integration with other non-supply chain ITN programming tools and other health commodity programming tools

AMP CONTACTS

To join the weekly AMP conference call each Wednesday at 10:00 AM Eastern time (16.00 PM CET) use the following Zoom meeting line:
https://us06web.zoom.us/j/88935481892?pwd=h3cuJ3x5LOsR58YXcEaub8ULqu5LMj.1

To find your local number to join the weekly call:
https://zoom.us/u/acyOjklJj4

To be added to the AMP mailing list visit:
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To contact AMP or join an AMP working group please e-mail:
info@allianceformalariaprevention.com

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