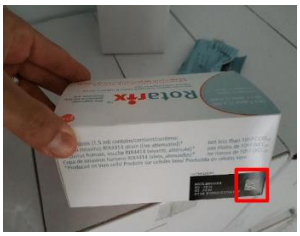
Barcodes

Comparator: Use without innovation (i.e. no barcodes)

Section 1: Summary of innovation

1.1 Example images:

Primary package barcode[a]	Secondary package barcode[b]	Tertiary package barcode[c]
		

1.2. Description of innovation:

- Barcodes are symbols that encode information such as product numbers, serial numbers, supplier data, batch numbers and expiry dates which can be scanned electronically using 2 dimensional (2D) scanners, laser or mobile device cameras to automatically capture information.
- Barcodes can be placed on vaccine primary, secondary, and tertiary packaging. This evaluation assumes barcode placement down to the primary packaging level.
- 2D barcodes are a Data Matrix capable of holding a significant amount of information (more than the linear one-dimensional barcodes) in a smaller space. The 2D barcodes currently available on some vaccines contain the vaccine product identification information, expiration date and lot number[d].
- Barcodes enable tracking and monitoring of vaccine products in supply chains, providing information to manufacturers, transport providers, health facilities and other relevant parties involved in the logistics management systems, assuming the supporting infrastructure is in place.
- Providers can use barcode scanners to read the 2D barcodes on primary packaging and automatically import data into patient electronic medical records (EMRs), if these EMRs are in place.

[a] Photo source: https://www.newswire.ca/news-releases/sanofi-pasteur-moves-national-immunization-strategy-forward-with-new-bar-code-technology-509575151.html

[b] Photo source: PATH/Matt Morio
[c] Photo source: https://ediacademy.com/blog/freds-barcode-requirements/
[d] About Two-Dimensional (2D) Vaccine Barcodes, CDC. https://www.cdc.gov/vaccines/programs/iis/2d-vaccine-barcodes/about.html

1.3 Examples of innovations and developers:

Table 1.

Product name; Image	**Developer (place); website**	**Brief description, notes**
GS1 Data Matrix – a 2D barcode.	GS1 (New Jersey); https://www.gs1.org/ Guidelines have been developed for the application of GS1 Data Matrix for vaccines[e].	WHO currently recommends GS1 compliant barcodes for secondary and tertiary packaging of vaccines containing the Global Trade Item Number (GTIN), vaccine expiry date and vaccine batch/lot number. This recommendation is anticipated to soon become a critical characteristic necessary for WHO prequalification as describe on page 13 of the WHO handbook for Assessing the programmatic suitability of vaccine candidates for WHO prequalification [f] .

[e] American Academy of Pediatrics & GS1 Healthcare US Guideline for Suppliers: https://www.gs1us.org/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core_Download&EntryId=628
[f] Assessing the programmatic suitability of vaccine candidates for WHO prequalification (page 13). http://apps.who.int/iris/bitstream/handle/10665/148168/WHO_IVB_14.10_eng.pdf?sequence=1&ua=1

SECTION 2: Summary of assessment for prioritisation

2.1 Key benefits:

- Improved quality and accuracy of inventory and immunization data for stock management, traceability in supply chains, patient vaccination records, and surveillance, which all contribute towards reducing missed opportunities (1). A study had shown that scanning of 2D barcodes on vaccines to capture data on lot number and expiration date was more accurate than using traditional methods (2).
- Standardization of vaccine product information on tertiary, secondary, and primary barcode labels for use along the continuum of tracking and tracing vaccines by manufacturers and country immunization programmes.

2.2 Key challenges:

- Increased resources and equipment required, including scanners, software, computers and network connectivity, and integration with electronic data capture systems. Additional training needs might also be a barrier.

2.3 Additional important information

- UNICEF wants to apply barcoding to their SAP- ERP system to improve tracking of their supply operations and to link GS1 standards in an effort for global standardization of data (UNICEF, personal communication).
- Countries can begin using barcodes on their own timelines and many are ready to do so, but the barcodes must first be available and standardized on vaccine products to make this possible.
- Smaller unit dose vials can be problematic for scanners to read due to greater curvature of the barcode, thus there is a need to ensure optimal barcode readability by the available scanning technology.

2.4 Evidence

- In Tanzania, barcodes were introduced as a pilot study into their electronic logistic management information system (eLMIS) for automated capturing of data of vaccine products, lot # and expiry dates. The observed benefits from this was a reduction in the excessive manual handing of the inventory, time involved in managing the inventory and wastage of expired vaccines (3).
- In the Nicaraguan national vaccine supply chain, 7 different sites had implemented a tool known as the Vaccines Visibility System (VVS) with an integrated barcode scanning and data processing system. The benefits encountered from this was time saving and ease of obtaining information, as well as a high rate of satisfaction by users due to improved data collection and reporting processes (personal communication Pfizer).
- Other countries (Gambia, Ethiopia and Pakistan) that are piloting barcodes within their country vaccine supply chains include (personal communication Pfizer):

  Ethiopia Pilot for end to end Supply Chain Visibility

  - USAID piloted the HCMIS GS1 Barcode Reader mobile application designed to scan GS1 barcodes available on pharmaceutical products during warehouse transactions using a

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mobile CMOS camera. Application supported multiple barcode types, however, pilot reported difficulties in effectively capturing barcode data on mobile smartphones as opposed to hardware scanners.

Implementation of GS1 Standards in Pakistan

- USAID piloted a vLMIS Scanner Application to scan GS1 barcodes on vaccines. However, barcodes were not available on sub-secondary and primary pharmaceutical packaging, limiting scope of barcode usage at supply chain levels lower than the provincial & national levels.

SECTION 3: Evaluation criteria

3.1 Health impact criteria

Indicator: Ability of the vaccine presentation to withstand heat exposure

*Legend: Green: **Better** than the comparator: The innovation includes features that may increase heat stability; White: **Neutral**, no difference with the comparator; Red: **Worse** than the comparator: The innovation includes features that may decrease heat stability, N/A: the indicator measured is **not applicable** for the innovation; Grey: **no data** available to measure the indicator.*

Table 2.

Ability of the vaccine presentation to withstand heat exposure	Parameters to measure against a comparator	Score	Assessment
	Does the innovation have features that may improve heat stability?	Neutral	Barcodes do not impact heat stability of a vaccine, which is no different to the comparator.

	***No difference** to comparator*

Indicator: Ability of the vaccine presentation to withstand freeze exposure

*Legend: Green: **Better** than the comparator: The innovation includes features that may increase heat stability; White: **Neutral**, no difference with the comparator; Red: **Worse** than the comparator: The innovation includes features that may decrease heat stability, N/A: the indicator measured is **not applicable** for the innovation; Grey: **no data** available to measure the indicator.*

Table 3.

Ability of the vaccine presentation to withstand freeze exposure	Parameters to measure against a comparator	Score	Assessment
	Does the innovation have features that may improve freeze resistance?	Neutral	Barcodes have no impact on the ability of the vaccine to withstand freeze exposure, which is no different to the comparator.

	***No difference** to comparator*

3.2 Coverage and equity criteria

Indicator: Ease of use[g]

*Legend: Dark Green: **Considerably better** than the comparator: Better for all applicable parameters; Green: **Better** than the comparator: Better for some of the applicable parameters AND no difference for the rest of the parameters; White: **Neutral**, no difference with the comparator; Yellow: **Mixed**: Better than the comparator for some of the applicable parameters AND worse than the comparator for the rest of the parameters; Red: **Worse** than the comparator: Worse for some of the applicable parameters AND no difference for the rest of the parameters; Dark Red: **Considerably worse** than the comparator: Worse for all applicable parameters, N/A: the indicator measured is **not applicable** for the innovation; Grey: **no data** available to measure the indicator.*

Table 4.

Ease of use	Parameters to measure against a comparator	Score	Assessment
• *Assessment of the potential for incorrect preparation based on usability data from field studies (or based on design of innovation if field studies not available)* • *Assessment of the potential for incorrect administration based on usability data from field studies (or based on design of innovation if field studies not available)*	**Does the innovation avoid reconstitution and is that an improvement?**	Neutral	Labelling of vaccine primary containers with barcodes has no impact on reconstitution, which is no different to the comparator.
	Does the innovation require fewer vaccine product components?	Neutral	A vaccine primary container with a barcode would have the same number of vaccine product components as a vaccine without a barcode (comparator) because the barcode is integrated into the existing vaccine label.
	[h] **Does the innovation require additional components or equipment (such as scanners or label readers)?**	Worse	Additional equipment (e.g. reader for scanning barcode) would be necessary for capturing and processing data/information provided in the barcode. This would also increase the number of steps and complexity, compared to having no barcoding system.
	Does the innovation require fewer preparation steps and less complex preparation steps?	Neutral	A primary container with a barcode will have the same number and complexity of vaccine preparation steps as the comparator. The barcode could provide a link to online guidance in preparing the vaccine correctly (4). However, the vaccine would still be prepared the same way as without the innovation.

[g] Ease of use can prevent missed opportunities resulting from the complexity of preparation and administration procedures. It could also impact the ability for lesser trained personnel to administer the vaccine (incl. self-administration). It can be assessed based on usability data from field studies (or based on design of innovation if field studies not available).
[h] This parameter is only assessed for RFID/barcodes, for all other innovations it is not applicable (N/A).

Category: *Labelling*
Innovation: *Barcodes*
Comparator: *No barcodes*

Ease of use • *Assessment of the potential for incorrect preparation based on usability data from field studies (or based on design of innovation if field studies not available)* • *Assessment of the potential for incorrect administration based on usability data from field studies (or based on design of innovation if field studies not available)*	**Parameters to measure against a comparator**	**Score**	**Assessment**
	Does the innovation improve dose control?	Neutral	Barcodes could theoretically link the vaccinator to information about dose volume. However, this information is already part of most vaccine labelling.
	Does the innovation improve targeting the right route of administration?	Neutral	Barcodes do not have a direct impact on targeting the right route of administration, as this would be related to the role of the vaccinator, hence there is no difference to the comparator. Although not used for assessing vaccines, there is a systematic review on barcoding of medication in which studies had shown a reduction in the wrong route of administration errors prior to reaching the patient based on the barcode medication administration system (BCMA) that enables the nurse to access information to ensure the right patient is given the correct dose, at the right time via the right route (1,5).

	Worse *for the comparator*

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Indicator: Potential to reduce stock outs based on the number of separate components necessary to deliver the vaccine or improved ability to track vaccine commodities

*Legend: Green: **Better** than the comparator for one of the parameters; White: **Neutral**, no difference with the comparator; Red: **Worse** than the comparator for one of the parameters, N/A: the indicator measured is **not applicable** for the innovation; Grey: **no data** available to measure the indicator.*

Table 5.

Potential to reduce stock outs based on the number of separate components necessary to deliver the vaccine or improved ability to track vaccine commodities • *Assessment of the potential to reduce stock outs based on the innovation's features*	**Parameters to measure against a comparator**	**Score**	**Assessment**
	Does the innovation require fewer components?	Neutral	As barcodes are already on the vaccine packages during storage/transport, and any additional equipment (e.g. scanner/reader) required for this innovation is assumed to be in stock, the innovation would have the same number of components as the comparator. It is assumed that there would be no difference in the components required to deliver the vaccine than with the comparator.
	Or does the innovation include labelling that facilitates product tracking and is it better than the comparator?	Better	The integration of barcodes on vaccine packaging could improve tracking and tracing of vaccine commodities, resulting in reduced stock-outs due to improved stock management, which would be better than the comparator. Furthermore, barcodes could potentially improve accuracy of health records and reduced missed opportunities, which was demonstrated in a pilot study using barcodes to automatically record immunization data directly into a patient's health record.[i] However, this score is based on the assumption that Gavi-supported countries have electronic immunization registries in place nationwide in the future.

	Better *than the comparator*

[i] The Automated Identification of Vaccines (Bar Coding) Pilot Project. https://cdc.confex.com/cdc/nic2005/techprogram/paper_7714.htm

Indicator: Acceptability of the vaccine presentation and schedule to patients/caregivers

*Legend: Dark Green: **Considerably better** than the comparator: Better for all applicable parameters; Green: **Better** than the comparator: Better for some of the applicable parameters AND no difference for the rest of the parameters; White: **Neutral**, no difference with the comparator; Yellow: **Mixed**: Better than the comparator for some of the applicable parameters AND worse than the comparator for the rest of the parameters; Red: **Worse** than the comparator: Worse for some of the applicable parameters AND no difference for the rest of the parameters; Dark Red: **Considerably worse** than the comparator: Worse for all applicable parameters, N/A: the indicator measured is **not applicable** for the innovation; Grey: **no data** available to measure the indicator.*

Table 6.

Acceptability of the vaccine presentation to patients/ caregivers • *Does the innovation include features that may improve acceptability of vaccinees and caregivers*	**Parameters to measure against a comparator**	**Score**	**Assessment**
	Painful or not painful	Neutral	The inclusion of a barcode has no impact on pain, which is no different to the comparator without a barcode.
	Perception of ease of administration (i.e. convenience for the vaccinees/caregivers)	Neutral	Vaccinees and caregivers would not interact with barcodes/vaccine labelling innovations and it is expected that inclusion of a barcode on primary containers would not impact their perception of ease of administration, which would be no different to the comparator without a barcode label.
	Any other tangible benefit to improve/impact acceptability to vaccinees/caregivers	Better	Barcodes can potentially improve patient safety in terms of reducing errors for drug administration and timeliness/accuracy of documentation of data in health records (2). Application of this to immunization programmes could improve patients/caregivers access to vaccines and therefore satisfaction. A study by Uy *et al* had reported that barcode medication administration systems had reduced the incidence of medication errors by more than 50%, and the risk of adverse drug events by 11% or approximately 20 events per day (6). A systematic review on barcoding had shown a reduction in errors related to wrong dosing, dispensing and administration of medication prior to reaching the patient (5). Barcodes could potentially reduce the risk of incorrect vaccine dose preparation by improving inventory/stock management and ensuring that the appropriate vaccine components (e.g., lyophilized vaccine and diluent) are kept together. They can also provide links to data on websites with dosing, preparation and administration information for the healthcare provider, if internet access is available. There is vaccine specific data on this.

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		Better *than the comparator*

3.3 Safety Criteria

Indicator: Likelihood of contamination

*Legend: Dark Green: **Considerably better** than the comparator: Better for all applicable parameters; Green: **Better** than the comparator: Better for some of the applicable parameters AND no difference for the rest of the parameters; White **Neutral**, no difference with the comparator; Yellow: **Mixed**: Better than the comparator for some of the applicable parameters AND worse than the comparator for the rest of the parameters; Red: **Worse** than the comparator: Worse for some of the applicable parameters AND no difference for the rest of the parameters; Dark Red: **Considerably worse** than the comparator: Worse for all applicable parameters, N/A: the indicator measured is **not applicable** for the innovation; Grey: **no data** available to measure the indicator.*

Table 7.

Likelihood of contamination • *Risk assessment of potential for contamination based on design of innovation and on usability data from field studies*	Parameters to measure against a comparator	Score	Assessment
	Does the innovation reduce the risk of contamination while reconstituting the dry vaccine?	Neutral	The innovation would have the same risk of contamination as the comparator without a barcode. Barcodes can provide links to information on correct delivery/administration of medication to patients which promotes safety and medical quality (7). Based on this evidence, information incorporated into a barcode has the potential to guide the user by providing information on methods for reducing the risk of contamination while reconstituting a dry vaccine. However, as most of this information is already provided with the vaccine in the form of leaflets, the innovation would likely not reduce the risk of contamination while reconstituting the dry vaccine compared to the comparator.
	Does the innovation reduce the risk of contamination while filling the delivery device?	Neutral	The innovation would have no impact on the risk of contamination while filling the delivery device as with the comparator. This parameter would depend on the vaccine/delivery device.
	Does the innovation require fewer preparation steps and less complex preparation steps?	Neutral	A barcode on a primary container will have the same number and complexity of vaccine preparation steps as the comparator. The information incorporated into a barcode could provide the vaccinator guidance in preparing the vaccine correctly, through communicating vaccine related information (4). However, the vaccine would still be prepared the same way as without the innovation.

Likelihood of contamination • *Risk assessment of potential for contamination based on design of innovation and on usability data from field studies*	Parameters to measure against a comparator	Score	Assessment
	Does the innovation reduce the potential risk of reuse of delivery technology?	Neutral	The innovation would have no impact on the potential risk of reuse of the delivery technology, which would be the same for the comparator with no barcode labelling.
	Does the innovation reduce the risk of use of nonsterile components?	Neutral	The innovation would have no impact on the risk of use of nonsterile components, which would be the same for the comparator with no barcode labelling.

	No difference *to the comparator*

Indicator: Likelihood of needle stick injury

*Legend: Dark Green: **Considerably better** than the comparator: Better for all applicable parameters; Green: **Better** than the comparator: Better for some of the applicable parameters AND no difference for the rest of the parameters; White: **Neutral**, no difference with the comparator; Yellow: **Mixed**: Better than the comparator for some of the applicable parameters AND worse than the comparator for the rest of the parameters; Red: **Worse** than the comparator: Worse for some of the applicable parameters AND no difference for the rest of the parameters; Dark Red: **Considerably worse** than the comparator: Worse for all applicable parameters, N/A: the indicator measured is **not applicable** for the innovation; Grey: **no data** available to measure the indicator.*

Table 8.

Likelihood of needle stick injury • *Risk assessment of the presence of sharps during the process of preparing and administering the vaccine*	Parameters to measure against a comparator	Score	Assessment
	Does the innovation contain fewer sharps?	Neutral	Barcodes is a needle-free innovation and the use of a barcode has no impact on the number of sharps, which would be the same for the comparator with no barcode labelling.
	Does the innovation use sharps for preparing and/or administering the vaccine and is that better than the comparator?	Neutral	Barcodes is a needle-free innovation and the use of sharps would depend on the vaccine/delivery device. This would be the same for the comparator with no barcode labelling.

Likelihood of needle stick injury • *Risk assessment of the presence of sharps during the process of preparing and administering the vaccine*	Parameters to measure against a comparator	Score	Assessment
	Does the innovation include an auto disable feature and is that better than the comparator?	Neutral	As barcodes is a needle-free innovation, there is no risk of needle-stick injury, which is similar to the comparator with no barcode labelling. Therefore, neither innovation and the comparator require an autodisable feature. The auto disable features would depend on the vaccine/delivery device.
	If the innovation uses sharps, does it include a sharps injury prevention feature and is that better than the comparator?	Neutral	Barcodes is a needle-free innovation and the use of sharps would depend on the vaccine/delivery device. This would be the same for the comparator with no barcode labelling. Therefore, neither innovation and the comparator require a SIP feature.
	Does the innovation reduce the risk of injury after vaccine administration?	Neutral	Barcodes has no impact on the risk of needle-stick injury after vaccine administration. This would be the same for the comparator with no barcode labelling.

	No difference *to the comparator*

3.4 Economic costs criteria

Indicator: Total economic cost of storage and transportation of commodities per dose[j]

*Legend: Dark Green: **Considerably better** than the comparator: Reduces the volume per dose for applicable parameters; Green: **Better** than the comparator: Reduces the volume per dose for either of the applicable parameter, and there is no difference for the other; White: **Neutral**, no difference with the comparator; Yellow: **Mixed**: Reduces the volume for one of the parameter, and increases the volume for the other parameter compared to the comparator; Red: **Worse** than the comparator: Increases the volume per dose for either of the applicable parameters, and there is no difference for the other; Dark Red: **Considerably worse** than the comparator: Increases the volume per dose for both parameters, N/A: the indicator measured is **not applicable** for the innovation; Grey: **no data** available to measure the indicator.*

[j] The assessment of the indicator is volume-related and builds upon PATH's VTIA analysis. A directional estimation is made at this stage, and a better evaluation will be done in Phase II with more antigen-specific data.

Table 9.

Total economic cost of storage and transportation of commodities per dose	Parameters to measure against a comparator	Score	Assessment
	Does the innovation reduce the volume per dose stored and transported in the cold chain?	Neutral	As barcodes are part of vaccine labelling and do not change the volume of the vaccine or vaccine delivery devices, there is no difference with the comparator.
	Does the innovation reduce the volume per dose stored and transported out of the cold chain?	Neutral	Similar to above, barcodes are part of vaccine labelling and do not change the volume of the vaccine or vaccine delivery devices, so there is no difference with the comparator.

	No difference *to the comparator*

Indicator: Total economic cost of the time spent by staff per dose

Legend: Dark Green: ***Considerably better*** *than the comparator: Reduces time for all applicable parameters; Green:* ***Better*** *than the comparator: Reduces time for either, and there is no difference for the other one; White:* ***Neutral****, no difference with the comparator; Yellow:* ***Mixed****: Reduces the time for one of the parameters, and increases the time for the other parameter; Red:* ***Worse*** *than the comparator: Increases the time for either of the applicable parameters; and there is no difference for the other one; Dark Red:* ***Considerably worse*** *than the comparator: Increases time for all applicable parameters, N/A: the indicator measured is* ***not applicable*** *for the innovation; Grey:* ***no data*** *available to measure the indicator.*

Table 10.

Total economic cost of the time spent by staff per dose	Parameters to measure against a comparator	Score	Assessment
	Does the innovation have attributes that can save time for the vaccinator in preparing and administering the vaccine?	Neutral	The innovation does not have any attributes that save time for the vaccinator in preparing and administering the vaccine.

Total economic cost of the time spent by staff per dose	Parameters to measure against a comparator	Score	Assessment
	[k]**Does the innovation have attributes that save time for staff involved in stock management?**	Better	The use of barcodes is likely to save time for staff involved in stock management, increase efficiencies in stock management, and increase visibility to product tracing throughout the supply chain (10). Barcodes can capture key product information quickly and error-free. Barcodes on vaccines, when used with a VIMS, allow for faster and precise inventory of products by enabling automatic identification and data capture of product information and automatically calculating dose quantities from scanning of secondary packaging (boxes).

	Better *than the comparator*

Indicator: Total economic cost of one-time/upfront purchases or investments required to introduce the vaccine presentation and of recurrent costs associated with the vaccine presentation (not otherwise accounted for)

*Legend: White: **Neutral**: NO there are no one-time/upfront or recurrent costs and this is not different than the comparator; Red: **Worse** than the comparator: YES there are one-time/upfront or recurrent costs.*

[k] This parameter only applies to barcodes and RFID to capture the benefits for stock management processes, not based on the number of components, but the specific features of the innovation.

Table 11.

Total economic cost of one-time/upfront purchases or investments required to introduce the vaccine presentation and of recurrent costs associated with the vaccine presentation (not otherwise accounted for)	Parameters to measure against a comparator	Score	Assessment
	Are there one-time upfront costs that will be incurred for use of this innovation or recurrent costs that will be incurred for use of this innovation?	Worse	Yes. Barcode have upfront costs for equipment such as the scanners, other hardware and software. Barcodes also have recurrent costs such as internet costs and maintenance costs. Similar to any innovation, there would be training costs associated with introducing the innovation.

	Worse *than the comparator*

3.5 Secondary criteria on potential breadth of innovation use

Indicator: Applicability of innovation to one or several types of vaccines

Table 12.

Applicability of innovation to one or several types of vaccines	Assessment
• *What vaccines/antigens does the innovation apply to, based on technical feasibility?*	This innovation could be applied to all vaccines. There are no restrictions based on technical feasibility.

Indicator: Ability of the technology to facilitate vaccine combination

Table 13.

Ability of the technology to facilitate novel vaccine combination • *Does the innovation facilitate novel combination vaccine products?*	**Assessment**
	The innovation has no impact on the ability to combine vaccines.

SECTION 4

4.1 Robustness of data:

Table 14.

Category	**Assessment**
Type of study	Field studies, expert opinions and manufacturer data available. Vaccine specific data available for 2D-barcoded products.
Inconsistency of results	Low
Indirectness of comparison • *Indicate the setting in which the study was conducted (low, middle or high income setting);* • *Comment if the data is on non-vaccine application of the innovation*	Barcode study in the field of medicines and hospital settings in HICs. Some field study data in LIC was available.

Overall assessment:	*Low to moderate*	*Due to range of studies and availability, of which some are vaccine and non-vaccine specific.*

4.2 List of technical experts, manufacturers and/or technology developers interviewed for inputs:

Table 15.

Expert/type	Organisation/contact details	Notes
Ulrike Kreysa, Vice-president	GS1 Global Office.	Interview conducted to get high level understanding on key benefits and challenges of barcodes with GS1 standards and insight and access to data on barcode implementation in LMICs
Kyra Faircloth	Pfizer	Same as above

4.3 List of technical experts, manufacturers and/or technology developers that have reviewed and provided feedback/input to the technical notes (TN):

Table 16.

Reviewers	Organisation/contact details	Notes
Fatema Kazi	GAVI, the Vaccine Alliance fkazi-external-consultant@Gavi.org	Developed and reviewed TN
Matt Morio	PATH, Supply Systems & Equipment Portfolio Mmorio@path.org	Reviewed TN
PATH Medical Device and Health Technology Team Debra Kristensen Courtney Jarrahian Mercy Mvundura Collrane Frivold	PATH Debra Kristensen dkristensen@path.org	Reviewed TN
Julian Hickling	Working in Tandem Ltd julian@workingintandem.co.uk	Reviewed TN

4.4 References:

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