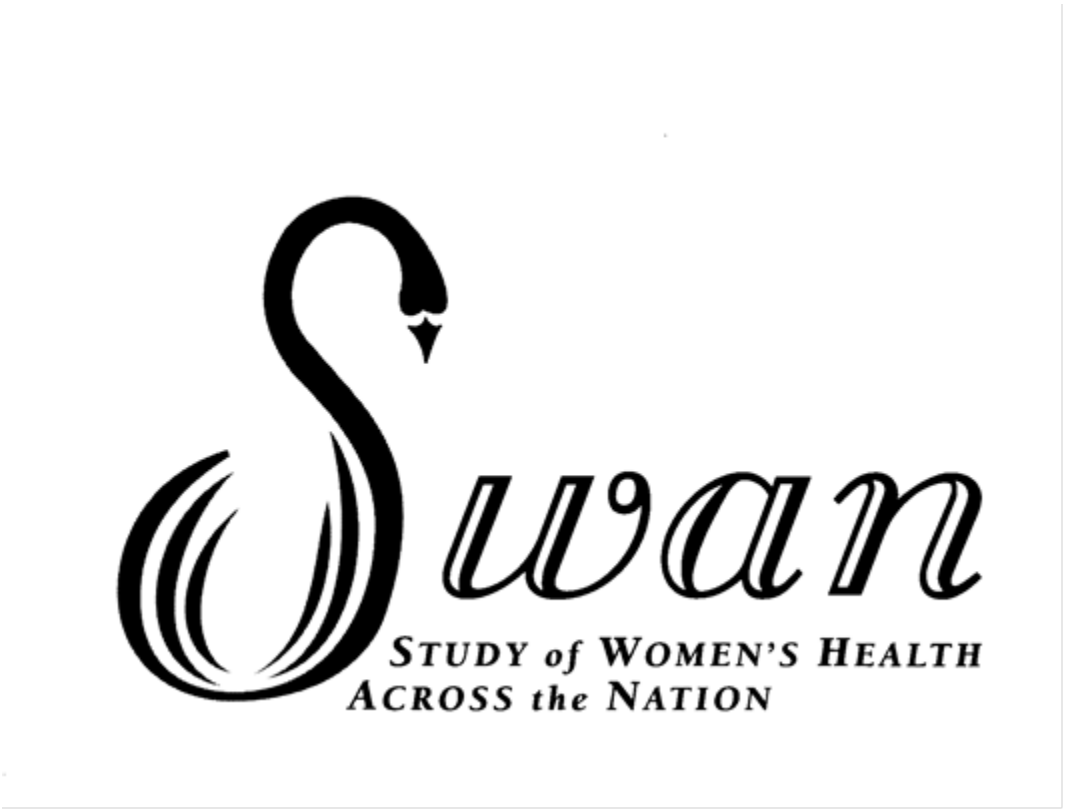

Visit 17 – Transthoracic Echocardiography Scan Dataset

CODEBOOK

ARCHIVED DATASET 2026

Dataset file niaecho2026

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DOCUMENTATION FOR THE SWAN VISIT 17 TRANSTHORACIC ECHOCARDIOGRAPHY SCAN DATASET

This dataset contains all Transthoracic Echocardiography Scan data for the SWAN cohort. This includes SWAN participants who were active as of follow-up Visit 17 and who completed Visit 17 transthoracic echocardiography study at the 6 participating SWAN study sites. This codebook contains detailed information on the ultrasound technology used to obtain the echocardiography measures in the echo dataset, as well as any other pertinent information for analysis.

Who is included in the public use dataset:

The dataset contains information for the 667 women who completed a transthoracic echocardiography scan (Echo) from the 6 participating SWAN clinical sites. The sites include 12, 13, 14, 15, 16, and 17.

The assigned participant ID has been replaced with a randomly generated ARCHID in order to protect participant privacy. The baseline interview date is denoted as day 0 and is used as the basis for all other dates. Variables describing the race/ethnicity of participants (RACE) was added from the Screener dataset. All variables contained within the dataset are listed in the first table below, with more detailed information in the pages following.

Missing data coding:

Original missing codes (-1: not applicable, -7: refused, -8: don't know, -9: missing) have been recoded to SAS missing codes (.B: not applicable, .D: refused, .C: don't know, and .A: missing).

Variables included in the dataset:

Variable	Label	Codes
ARCHID	Participant ID	
VISIT	Study Visit	"00" = Baseline to "17" = Visit 17
RACE	Race/Ethnicity	1 = Black 2 = Chinese/Chinese American 3 = Japanese/Japanese American 4 = White Non-Hispanic 5 = Hispanic
AGE17	Age at Visit	Continuous, rounded to nearest 0.1
SCAN_DAY	Day of Echo Scan	
ANLY_DAY	Day of Echo Analysis	
SCANTYP17	Echo Scan Type	1 = Complete scan 2 = Quick scan
IMAGEQ17	Echo Image Quality	1 = Unsatisfactory 2 = Good 3 = Excellent
PROCOMP17	Echo Protocol Compliance	1 = Unsatisfactory 2 = Good 3 = Excellent
QUALFLG17	Flag: Unsatisfactory Image Quality or Protocol Compliance	0 = Not Flagged 1 = Flagged
AORREG17	Aortic Regurgitation	0 = None 1 = Trace 2 = Mild 3 = Mild to Moderate 4 = Moderate 5 = Moderate to Severe 6 = Severe
MITREG17	Mitral Regurgitation	0 = None 1 = Trace 2 = Mild 3 = Mild to Moderate 4 = Moderate 5 = Moderate to Severe 6 = Severe

Variable	Label	Codes
TRIREG17	Tricuspid Regurgitation	0 = None 1 = Trace 2 = Mild 3 = Mild to Moderate 4 = Moderate 5 = Moderate to Severe 6 = Severe
PULREG17	Pulmonic Regurgitation	0 = None 1 = Trace 2 = Mild 3 = Mild to Moderate 4 = Moderate 5 = Moderate to Severe 6 = Severe
LVWABN17	LV Wall Motion Abnormalities	0 = None 1 = Anterior 2 = Septal 3 = Apical 4 = Posterior 5 = Lateral 6 = Inferior 7 = Global
VALCAL17	Valvular Calcification	0 = Neither 1 = Mitral 2 = Aortic 3 = Both
ESTCVP17	Estimated Central Venous Pressure (mmHg)	Numeric
GCSLV17	Global Circumferential Strain Mid LV	Numeric
HEARTRT17	Mitral Valve - Heart Rate (H.B./min)	Numeric
IVSD17	Left Ventricle - Interventricular Septum Thickness - End Diastole (mm)	Numeric
LVIDD17	Left Ventricle - Diastolic Minor Axis Dimension (mm)	Numeric
LVPWD17	Left Ventricle - Posterior Wall Thickness - End Diastole (mm)	Numeric
LVIDS17	Left Ventricle - Systolic Minor Axis Dimension (mm)	Numeric
LVOTD17	Left Ventricle Outflow Tract - Cardiovascular Orifice Diameter (mm)	Numeric
LVMASS17	Left Ventricle - Mass - Body Surface Area (g/m^2)	Numeric
EDVA4C17	Left Ventricle - End Diastolic Volume - Apical 4 Chamber (mL)	Numeric
ESVA4C17	Left Ventricle - End Systolic Volume - Apical 4 Chamber (mL)	Numeric
EFA4C17	Left Ventricle - Ejection Fraction - Apical 4 Chamber (%)	Numeric
EDVA2C17	Left Ventricle - End Diastolic Volume - Apical 2 Chamber (mL)	Numeric
ESVA2C17	Left Ventricle - End Systolic Volume - Apical 2 Chamber (mL)	Numeric
EFA2C17	Left Ventricle - Ejection Fraction - Apical 2 Chamber (%)	Numeric
EDVBP17	Left Ventricle - End Diastolic Volume - Biplane (mL)	Numeric
ESVBP17	Left Ventricle - End Systolic Volume - Biplane (mL)	Numeric
EFBP17	Left Ventricle - Ejection Fraction - Biplane (%)	Numeric
AVVMAX17	Aortic Valve - Peak Velocity - Antegrade Flow (m/s)	Numeric
LVOTVTI17	Left Ventricle Outflow Tract - Vel. Time Integral - Antegrade Flow (cm)	Numeric
LVOTSI17	Left Ventricle Outflow Tract - Stroke Index - Doppler Volume Flow (mL/m^2)	Numeric
MVEVEL17	Mitral Valve - E-Wave Peak Velocity - Antegrade Flow (cm/s)	Numeric
MVDECTIM17	Mitral Valve - E-Wave Deceleration Time - Antegrade Flow (ms)	Numeric
MVAVEL17	Mitral Valve - A-Wave Peak Velocity - Antegrade Flow (cm/s)	Numeric
MVEA17	Mitral E to A Ratio	Numeric
TDIEVS17	Left Ventricle TDI - Peak Early Diastolic Tissue Vel. - Septal Mitral Annulus (cm/s)	Numeric

Variable	Label	Codes
TDIEVL17	Left Ventricle TDI - Peak Early Diastolic Tissue Vel. - Lateral Mitral Annulus (cm/s)	Numeric
TDIMVEE17	Mitral E/e' - Ratio of MV Peak Vel. to Mean LV Peak Tissue Vel. E-Wave	Numeric
LVGLSE17	Left Ventricle - Global Longitudinal Strain - Endocardial - Triplane (%)	Numeric
LVGLSM17	Left Ventricle - Global Longitudinal Strain - Myocardial - Triplane (%)	Numeric
RVAD17	Right Ventricle - Area - End Diastole (cm^2)	Numeric
RVAS17	Right Ventricle - Area - End Systole (cm^2)	Numeric
RVFAC17	Right Ventricle - Fractional Area Change (%)	Numeric
TAPSE17	Right Ventricle - Tricuspid Annular Plane Systolic Excursion (mm)	Numeric
RVDDB17	Right Ventricle - Diameter - End Diastole - Basal (mm)	Numeric
TRVMAX17	Tricuspid Valve - Peak Velocity - Regurgitant Flow (m/s)	Numeric
LADS17	Left Atrium - Diameter - Systole - Antero-posterior (mm)	Numeric
LAVOLA4C17	Left Atrium - End Systolic Volume - Apical 4 Chamber (mL)	Numeric
LAVOLA2C17	Left Atrium - End Systolic Volume - Apical 2 Chamber (mL)	Numeric
LAVOLBP17	Left Atrium - End Systolic Volume - Biplane (mL)	Numeric
LAVOLI17	Left Atrium - End Systolic Volume Index - Biplane - Body Surface Area (mL/m^2)	Numeric
LAGLS17	Left Atrium - Global Longitudinal Strain (%)	Numeric
PASP17	Pulmonary Artery Systolic Pressure	Numeric
CARDIND17	Calculated Cardiac Index	Numeric
TDIEVAVG17	Calculated Average TDI e’ Velocity	Numeric
LVDFA17	Left Ventricular Diastolic Function Assessment	0=Normal Diastolic Function 1=Indeterminate 2=Diastolic Dysfunction 3=Normal, determined by lab
LVDDGR17	Left Ventricular Diastolic Dysfunction Grade	0=Normal 1=Grade I 2=Grade II 3=Grade III 4=Indeterminate 5=Normal, determined by lab

A. Transthoracic Echocardiography Assessment

Transthoracic echocardiography (TTE) is a non-invasive imaging technique used to evaluate the structure and function of the heart. It involves using ultrasound waves to create real-time images of the heart from outside the chest (transducer placed on the chest wall).

During the TTE, sound waves are emitted from the transducer and bounce off the various structures within the heart. The echoes produced by these sound waves are then detected by the transducer and converted into detailed images of the heart.

TTE images were acquired by skilled sonographers and physicians at 6 sites. The acquired images were subsequently uploaded to the DataStream application, a dedicated platform for managing echocardiographic data. To facilitate analysis and interpretation of the TTE studies, the Echo Core Lab at the University of Pittsburgh imported the acquired echo studies into TomTec software, a vendor-neutral specialized software program designed for advanced echocardiographic analysis. The TomTec software provides a comprehensive set of tools and features for in-depth evaluation of the TTE images, enabling the assessment of cardiac structure, function, and hemodynamics. This software allows for precise measurements, detailed quantification, and interpretation of the acquired TTE studies. By utilizing the DataStream application for data management and the TomTec software for analysis, the Echo Core Lab ensures standardized and efficient processing of the TTE studies.

B. Data Collection Detailed Methods

1. Image collection protocol and quality control

At each site, centrally trained and certified sonographers and physicians obtained transthoracic echocardiography images using different vendors (GE Health Care Systems, Philips EPIQ CVx, Mindray) equipped with variable frequency 5-12 MHz linear array transducers. The acquisition protocol was distributed to all sites to ensure compliance with the echo study protocol.

The acquisition protocol for the echo study was as follows:

1. Digital Data Acquisition: The standard approach involved using digital data acquisition for all studies, with recordings saved in the DICOM format.
2. DICOM Recording: Any echocardiography system with DICOM recording capabilities was utilized to save the studies in the appropriate format.
3. Uploading to Echo Core Lab: Echocardiograms were uploaded to the Echo Core Lab via the internet for analysis and storage.
4. Local Copy: In addition to uploading, a local copy of the digital DICOM study was kept on CD or another digital medium for archiving purposes.
5. ECG Signal: A high-quality ECG signal with a prominent R wave was obtained and recorded to facilitate gating of the digital acquisition system.
6. Gain Adjustment: The gain settings were slightly increased, aiming for optimal endocardial definition rather than decreasing it.
7. Breath Holding: Patients were instructed to hold their breath during the phase of respiration that provided optimal image clarity for each capture.
8. Capturing Sets: The standard practice involved obtaining 2 sets of 3-beat captures. The echo system was configured to capture 3 beats per set, resulting in a minimum of 6 beats per view. Additional beats and images were recorded if deemed beneficial.
9. Doppler Imaging: For Continuous Wave and Pulsed Doppler, two screens capturing 3-5 beats per screen were recommended. If premature ventricular or atrial beats were observed, more beats were recorded.
10. Depth Adjustment: The depth for apical images was adjusted to include the entire left atrium, and the same depth setting was maintained for all apical images and Doppler signals required by the protocol. Narrowing the sector angle for two-dimensional imaging was unnecessary.
11. Doppler Sweep Speed: Doppler spectral velocity signals were recorded at sweep speeds of 50-100/sec, and excessive use of the wall filter was avoided.
12. Doppler Gain and Scale: The gain and scale settings were optimized to ensure clearly defined spectral envelopes, maximizing the size of pulsed Doppler spectral velocity tracings while utilizing the baseline.
13. Color Flow Doppler: The frame rate for Color Flow Doppler was optimized by narrowing the sector angle.

The following protocol was completed for:

- Parasternal Long Axis view: 2-D recording at the standard depth were performed.
    i. Two sets of 3-beat captures were recorded.
    ii. A Color Doppler assessment of the left atrium for mitral regurgitation (MR) was captured using a 3-beat sequence. If MR was more than trivial, an additional 3-beat sequence for MR was recorded.
    iii. A 3-beat Color Doppler of the left ventricular outflow tract for aortic regurgitation (AR) was captured. If AR was more than trivial, an additional 3-beat sequence for AR was recorded.
- In the Right Ventricular Inflow view, the following assessments were carried out:
    i. A thorough color Doppler evaluation of tricuspid regurgitation (TR) was conducted.
    ii. The sweep speeds for Doppler imaging were set at 50-100 mm/sec.
    iii. Continuous wave Doppler was used to record the peak velocity of TR, with 2 screens captured for analysis.
- Parasternal Short Axis View Basal:
    i. The imaging was oriented at the base to visualize the right ventricular outflow tract (RVOT).
    ii. Pulsed Doppler was placed in the RVOT.
    iii. Spectral velocity sweep speeds were set at 50-100 mm/sec.
    iv. Two screens, each capturing 3-5 beats, were recorded.
- Parasternal Short Axis View, Mitral Valve level:
    i. The mid-left ventricular (LV) short axis view at the level of the mitral valve was obtained.
    ii. The LV was oriented as circular as possible.
    iii. Two sets of 3-beat captures were recorded.
- Parasternal Short Axis View, Mid-LV level:
    i. The mid-left ventricular (LV) short axis view at the level of the papillary muscles was acquired.
    ii. The LV was oriented as circular as possible.
    iii. Two sets of 3-beat captures were recorded.
- Apical 4 Chamber View:
    i. The image was oriented to visualize the maximal length from the left ventricular (LV) apex to the left atrium (LA).
    ii. The LV was centered in the sector.
    iii. Patients were instructed to hold their breath during the capture, ensuring optimal endocardial visualization.
    iv. Two sets of 3-beat captures were recorded, both with and without the atria.
    v. Color Doppler assessment of the left atrium (LA) for mitral regurgitation (MR) was performed using a 3-beat capture. If MR was more than trivial, an additional 3-beat capture for MR was recorded.
    vi. Color Doppler assessment of the right atrium (RA) for tricuspid regurgitation (TR) was conducted using a 3-beat capture. If TR was more than trivial, an additional 3-beat capture for TR was recorded.
- Pulsed Doppler of Mitral Inflow (from Apical 4-chamber View):
    i. Pulsed Doppler was performed at the tips of the mitral valve leaflets.
    ii. Spectral velocity sweep speeds were set at 50-100 mm/sec.
    iii. Two screens, each capturing 3-5 beats, were recorded for analysis.
- Pulsed-TDI Mitral Annulus (from Apical 4-chamber View):
    i. Pulsed Tissue Doppler was performed at the both lateral and medial mitral annulus.
    ii. Spectral velocity sweep speeds were set at 50-100 mm/sec.
    iii. Two screens, each capturing 3-5 beats, were recorded for analysis.
- Pulsed Doppler of LVOT (from 5-chamber view):
    i. The sample volume was placed approximately 1 cm from the aortic valve in the center of the left ventricular outflow tract (LVOT).
    ii. Spectral velocity sweep speeds were set at 50-100 mm/sec.
    iii. Two screens, each capturing 3-5 beats, were recorded for analysis.
- Continuous Wave (CW) Doppler of Aorta (from 5-chamber view):
    i. Continuous wave Doppler was placed through the center of the aortic valve.
    ii. Spectral velocity sweep speeds were set at 50-100 mm/sec.
    iii. Two screens, each capturing 3-5 beats, were recorded for analysis.

- Dedicated RV Apical 4-Chamber View:
    i. The image was acquired to capture the entire right ventricular (RV) free wall, even if the left ventricle (LV) is not included. This may involve adjusting the sector to obtain an "RV centered view."
    ii. Patients were instructed to hold their breath during the capture, ensuring optimal visualization of the endocardium.
    iii. Two sets of 3-beat captures were recorded.
    iv. Color Flow Doppler was used to obtain tricuspid regurgitant jets.
    v. Two sets of 3-beat captures using Color Flow Doppler were recorded.

- M-mode of Tricuspid Annulus (from Apical 4-chamber View, modified for RV) for Tricuspid Annular Plane Systolic Excursion (TAPSE):
    i. The M-mode imaging was used to measure Tricuspid Annular Plane Systolic Excursion (TAPSE) at the Tricuspid Annulus.
    ii. Sweep speeds were set at 50-100 mm/sec.
    iii. Two screens, each capturing 3-5 beats, were recorded for analysis.

- Continuous Wave Doppler of TR Velocity (from Apical 4-chamber View):
    i. Sweep speeds were set at 50-100 mm/sec.
    ii. Continuous Wave Doppler was used to measure the peak tricuspid regurgitant velocity.
    iii. Two screens, each capturing 3-5 beats, were recorded for analysis.

- Apical 2 Chamber View:
    i. The image was oriented to visualize the maximal length from the left ventricular (LV) apex to the left atrium (LA).
    ii. The entire LV apex was included in the image.
    iii. The LV was centered in the sector vertically as much as possible.
    iv. Patients were instructed to hold their breath during the capture, ensuring optimal visualization of the endocardium.
    v. Two sets of 3-beat captures were recorded, both with and without the left atrium.
    vi. Color Flow Doppler assessment of mitral regurgitation (MR) was performed if present.
    vii. Three sets of 3-beat captures using Color Flow Doppler for MR were recorded.

- Apical Long Axis View (3-chamber View):
    i. The image was oriented to maximize the visualization of the length from the left ventricular (LV) apex to the left atrium (LA).
    ii. The entire LV apex was included in the image.
    iii. The LV was centered in the sector vertically as much as possible.
    iv. Patients were instructed to hold their breath during the capture to ensure optimal visualization of the endocardium.
    v. Two sets of 3-beat captures were recorded, both with and without the left atrium.
    vi. Color Flow Doppler assessment of mitral regurgitation (MR) was performed if present.
    vii. Three sets of 3-beat captures using Color Flow Doppler for MR were recorded.

- Inferior Vena Cava (IVC) Assessment:
    i. The transducer was positioned to obtain an image of the open IVC.
    ii. The IVC was imaged with a longer clip, capturing 5-10 beats or during an inspiratory phase ("sniff").
    iii. Two longer clips of the IVC with inspiration were recorded for analysis.

2. Quick Scan

While a complete scan was preferred, it was occasionally determined to be impossible due to time constraints or other limitations. As a result, a quick scan protocol was implemented to ensure that essential assessments were performed within the available time frame. The Quick Scan protocol was performed only when a complete scan could not be performed. Each participant underwent a streamlined examination that targeted critical areas of interest, allowing for a preliminary evaluation of their cardiovascular status. Despite the abbreviated nature of the quick scan, efforts were made to cover a broad range of assessments to obtain relevant information for each participant.

Parasternal Long Axis, apical 4 chamber, apical 2 chamber and apical 3 chamber Views:

For each two sets of 3-beat captures were recorded for analysis.

- Pulsed Doppler of Mitral Inflow: (from Apical 4-chamber View):
    i. Pulsed Doppler was performed at the tips of the mitral valve leaflets.
    ii. Spectral velocity sweep speeds were set at 50-100 mm/sec.

iii. Two screens, each capturing 3-5 beats, were recorded for analysis.

- Pulsed-TDI Mitral Annulus (from Apical 4-chamber View):
  i. Pulsed Tissue Doppler was performed at the both lateral and medial mitral annulus.
  ii. Spectral velocity sweep speeds were set at 50-100 mm/sec.
  iii. Two screens, each capturing 3-5 beats, were recorded for analysis.

Upon the completion of the echo studies, the resulting images were subsequently transferred to the Data Stream platform. Subsequently, the echo scans were imported into the vendor independent software (TOMTEC-ARENA TTA2.50, Germany) for offline analysis by the echo core lab.

3. Assessments of Function

Assessment of left ventricular function:

Linear measurements of the left ventricle (LV) dimensions and LV walls (septum and posterior) are typically performed in the parasternal long-axis view. To ensure accuracy, septal and posterior wall thickness (at end diastole), end-diastolic and end-systolic LV dimensions, were obtained perpendicular to the LV long axis, from the parasternal long-axis view, specifically at or just below the level of the mitral valve leaflet tips.

The table on page 8 presents normal ranges for left ventricular (LV) diameters. A measurement of the interventricular septum exceeding 1.2 cm indicates left ventricular hypertrophy. LV mass was determined using the formula:

$$0.8 \times (1.04 \times (((LVEDD + IVSd + PWd)^3 - LVEDD^3))) + 0.6$$

An LV mass index exceeding 95 g/m^2 signifies an increase in LV mass [1].

LV volumes, including end-systolic volume (ESV) and end-diastolic volume (EDV) were assessed using echocardiography from the apical 4- and 2-chamber views. These measurements are used to determine LV ejection fraction (LVEF) by the Simpson method. LVEF < 40% indicates reduced, 41-49% mid-range, and LVEF ≥ 50% indicates preserved LVEF [2].

Blood flow across the left ventricular outflow tract (LVOT) is another parameter that reflects the LV function. It serves to calculate the forward stroke volume. Flow across LVOT is integrated over the time and used in the calculation of forward stroke volume (LVOT TVI x LVOT area). The normal reference values for stroke volume are typically within the range of 62 to 100 mL. When indexed to body surface area, the normal range is approximately 30 to 45 mL/m^2 [3].

For the assessment of global longitudinal strain (GLS), the LV endocardial border was manually traced at the end-diastolic and end systolic frames, in the apical 2-, 4-chamber and long-axis views. Endocardial and myocardial tracking quality was verified visually during the cardiac cycle. LV endocardial and myocardial global longitudinal strain were automatically computed as the average of segmental peak systolic strain values (total 17 segments). By definition, longitudinal strain is represented by negative values. Hence, values closer to 0 correspond to poorer cardiac function while more negative values indicate better LV function. GLS can detect subtle myocardial dysfunction earlier than measures of LVEF. An LVEF (≥ 50%) together with impaired LV GLS (endocardial GLS > -18 and myocardial GLS > -16) indicate subclinical LV systolic dysfunction. This suggests that despite a seemingly normal ejection fraction, there may be underlying myocardial abnormalities, particularly affecting the longitudinal function of the LV [4].

Circumferential strain was measured from the midventricular short axis images. The global circumferential strain was computed as the average of peak systolic strain value of 6 mid LV segments. Longitudinal and circumferential strain represent LV deformation in 2 orthogonal planes and are complementary to each other [2]. Similar to GLS, negative circumferential strain indicates normal systolic shortening of the LV; Normal cut off is -23% [5]. Thus, values closer to 0 correspond to poorer cardiac function.

Assessment of left atrial (LA) function:

Linear measurement for LA diameter was performed from the parasternal long axis view at end systole. LA volume is the average value obtained from the apical 2- and 4-chamber. If the LA volume indexed to body surface area (BSA), exceeds 34 mL/m^2, the LA is considered dilated. However, atrial size is not necessarily the only manifestation of poor atrial function.

LA strain provides complementary information about LA dysfunction and may precede LA dilatation. LA strain was computed by a similar approach to LV longitudinal strain from the apical 4- and 2-chamber atrial focused views through tracking the LA endocardial border during the cardiac cycle. The software generated, from each individual view, the average longitudinal LA deformation and the average of apical 2- and 4-chambers as well. Peak atrial longitudinal strain (PALS) represents the reservoir function of the LA. A lower limit of normal for PALS is considered to be 21% [7,8]. PALS is represented by positive values because of the atrial expansion during ventricular systole. Hence higher values represent better LA function.

Assessment of right ventricular function:

RV basal diameter >41 mm indicates RV dilation. TAPSE (tricuspid annular plane systolic excursion), serves as a measure of RV longitudinal function. TAPSE is <16 mm indicates reduced RV systolic function. Two-dimensional fractional area change (FAC), expressed as a percentage, is another measure of RV systolic function. FAC is computed using the formula:

(RV end diastolic area – RV end systolic area) / RV end diastolic area.

FAC <35%, indicated RV systolic dysfunction. These measurements are obtained from the RV focused apical 4-chamber view. There is no consensus for the evaluation of RV diastolic function [1,9].

Doppler measurements and assessment of inferior vena cava:

All Doppler measurements were performed by using continuous wave (CWD) and pulsed wave Doppler (PWD) tools for the blood flow across the valves and LVOT and by using the tissue Doppler tool (TDI, to obtain E' velocity from septal and lateral mitral annulus) for the tissue velocity.

E' velocity obtained by tissue Doppler takes part in the assessment of diastolic function. LVOT VTI is utilized to compute stroke volume and cardiac index, as described previously. The normal value for aortic peak velocity is less than 2.5 m/s. Aortic peak velocities between 2.6 and 2.9 m/s indicate mild aortic stenosis, while velocities between 3.0 and 4.0 m/s suggest moderate aortic stenosis. Aortic stenosis can be considered severe if the peak velocity is greater than 4.0 m/s [10].

Inferior vena cava (IVC) diameter is measured in the subcostal view with the patient in the supine position at 1.0 to 2.0cm from the junction with the right atrium. The diameter of the IVC and the percent decrease in the diameter during inspiration correlate with right atrial pressure.

In addition, for the estimation of systolic pulmonary artery pressure, whenever a tricuspid regurgitant jet velocity >2 m/s was obtainable the following formula was used: ($4v^2$ + estimated right atrial pressure) where v is the peak tricuspid regurgitant (TR) jet velocity and right atrial pressure (central venous pressure) is estimated from the inferior vena cava collapse and diameter (diameter <21 mm and inspiratory collapse >50% are considered normal, when both are normal; the estimated right atrial pressure is 3, when one of the parameters is outside these limits; the estimated right atrial pressure is 8, when both are abnormal the estimated right atrial pressure is assumed to be 15 mmHg). Considering the potential error in estimating the right atrial pressure, the current guidelines recommend using the peak TR velocity (and not the estimated sPAP) as the key variable for assigning the echocardiographic probability of pulmonary hypertension. A peak TR velocity greater than 2.8 m/s is suggestive of pulmonary hypertension (PH) [11].

In the setting of preserved LVEF (EF>50%), LV diastolic dysfunction (DD) is considered present if more than 2 of the following criteria are met:

1- E/e' ratio > 14;
2- Septal e' velocity < 7 cm/s or lateral e' velocity < 10 cm/s;
3- Maximum LA volume index (LAVI) > 34 ml/m^2;
4- TR velocity > 2.8 m/s.

If fewer than 2 criteria are met, it suggests normal LV diastolic function. If 2 criteria are met this is considered indeterminate.

For the evaluation of LV DD grade, mitral E/A ratio, E/e' ratio, TR velocity, and LA volume index are assessed. The grading classification of LV DD is performed when LV EF≤50% or when LVEF is normal and DD criteria have been met (more than 2 criteria described above). In LVDD grade I, LA pressure is typically normal. However, in grades II and III LV DD, LA pressure is increased [12,13].

4. Echocardiogram Variables – Measured and Created

The TomTec results spreadsheet provides over 300 individual measures for the echocardiography scan, however not all of these variables are necessary for analysis. The scan results have thus been narrowed down to 39 directly measured variables and 13 created variables. In addition to differentiating by heart chamber, echocardiographic variables can be categorized in 2 parts as functional (related to heart muscle performance and blood flow dynamics) and structural (related to morphological characteristics). All measured and created variables from the echo scans are detailed in the following tables, including their structural/functional categorization, anticipated ranges*****, and unit of measure.

***Note on anticipated ranges:* All values were checked for outliers based on these ranges and other statistical methods. Identified cases were sent to the lab for confirmation/corrections. Any values still outside of these expected ranges have been checked and confirmed by the echo core lab.**

Table 3: Measured Variables

MEASUREMENT	ABBREVIATIONS	SAS NAME	RANGE/UNIT	CATEGORY
Heart Rate	HR	HEARTRT17	40-120/min	-
LEFT VENTRICAL				
Septal Thickness (diastole)	IVSd	IVSD17	6-14 mm	Structural
LV Dimension (diastole)	LVIDd	LVIDD17	38-70 mm	Structural
Posterior Wall Thickness (diastole)	LVPWd	LVPWD17	6-14 mm	Structural
LV Dimension (systolic)	LVIDs	LVIDS17	22-50 mm	Structural
LVOT Diameter (systole)	LVOT diam	LVOTD17	16-29 mm	Structural
LV Mass (linear method)	LV Mass Penn, LV Mass I	LVMASS17	43-250 g/m^2	Structural
End-Diastolic Volume (4-Ch)	EDV (A4C)	EDVA4C17	46-300 mL	Functional
End-Systolic Volume (4-Ch)	ESV (A4C)	ESVA4C17	14-150 mL	Functional
Ejection Fraction (4-Ch)	EF (A4C)	EFA4C17	15-70%	Functional
End-Diastolic Volume (2-Ch)	EDV (A2C)	EDVA2C17	46-300 mL	Functional
End-Systolic Volume (2-Ch)	ESV (A2C)	ESVA2C17	14-150 mL	Functional
Ejection Fraction (2-Ch)	EF (A2C)	EFA2C17	15-70%	Functional
End-Diastolic Volume (Biplane)	EDV (BP)	EDVBP17	46-300 mL	Functional
End-Systolic Volume (Biplane)	ESV (BP)	ESVBP17	14-150 mL	Functional
Ejection Fraction (Biplane)	EF (Simpson BP), EF (BP)	EFBP17	15-74%	Functional
Continuous Wave Doppler Aorta	AV max	AVVMAX17	1-4 m/s	Functional
Pulsed Doppler LVOT VTI	LVOT VTI	LVOTVTI17	12-35 cm	Functional
Stroke Volume Index	SV index	LVOTSI17	25-65 mL/m^2	Functional
MV Peak E Velocity	MV E Vel	MVEVEL17	40-200 cm/s	Functional
MV Deceleration Time	MV Dec. Time	MVDECTIM17	100-300 ms	Functional
MV Peak A Velocity	MV A Vel	MVAVEL17	40-200 cm/s	Functional
Mitral E to A Ratio	E/A	MVEA17	0.5-4	Functional
TDI E' Velocity (septal)	E'(s), E/E'(s)	TDIEVS17	2-22 cm/s	Functional
TDI E' Velocity (lateral)	E'(l), E/E'(l)	TDIEVL17	2-22 cm/s	Functional
Mitral E/e'	E/E' mean	TDIMVEE17	-	Functional
Global Longitudinal Strain (endo)	EndoGLS (A4CA2CA3C)	LVGLSE17	< -11%	Functional
Global Longitudinal Strain (myo)	MyoGLS (A4CA2CA3C)	LVGLSM17	< -11%	Functional
RIGHT VENTRICLE				
RV End-Diastolic Area	RVAd	RVAD17	8-35 cm^2	Structural
RV End-Systolic Area	RVAs	RVAS17	2-20 cm^2	Structural
RV Fractional Area Change	RV FAC	RVFAC17	30-60%	Functional
Tricuspid Annular Plane Systolic Excursion	TAPSE	TAPSE17	12-35 mm	Functional
RV Basal Diameter	RVDd base (RVD1)	RVDDB17	25-55 mm	Structural
TR Peak Velocity	TR Vmax	TRVMAX17	1-4 m/s	Functional
LEFT ATRIUM				
LA Diameter (max)	LA diam systole	LADS17	27-60 mm	Structural
LA Volume (4-Chamber)	LA Vol (A4C)	LAVOLA4C17	27-150 mL	Structural
LA Volume (2-Chamber)	LA Vol (A2C)	LAVOLA2C17	27-150 mL	Structural
LA Volume (Biplane)	LA Vol (BP)	LAVOLBP17	27-150 mL	Structural
LA Volume Index	LA Vol I (BP)	LAVOLI17	20-80 mL/m^2	Structural
LA Strain	EndoGLS (LA), PALS	LAGLS17	21-68%	Functional

Table 4: Created Variables

MEASUREMENT	ABBREVIATIONS	SAS NAME	RANGE/UNIT	CATEGORY
Cardiac Index	CI	CARDIND17	L/min/m^2	Functional
Global Circumferential Strain	GCS	GCSLV17	%	Functional
Estimated CVP from IVC	CVP	ESTCVP17	≤3 mmHg	Functional
PA Systolic Pressure	PAPs	PASP17	15-70 mmHg	Functional
TDI E' Velocity (Average)	-	TDIEVAVG17	cm/s	Functional
Aortic Regurgitation	AR	AORREG17	0=None 1=Trace 2=Mild 3=Mild-Mod 4=Moderate 5=Mod-Severe 6=Severe	Functional
Mitral Regurgitation	MR	MITREG17		Functional
Pulmonic Regurgitation	PR	PULREG17		Functional
Tricuspid Regurgitation	TR	TRIREG17		Functional
LV Wall Motion Abnormalities	-	LVWABN17 LVWDET17	0=None 1=Anterior 2=Septal 3=Apical 4=Posterior 5=Lateral 6=Inferior 7=Global	Functional
Valvular Calcification (Mitral/Aortic)	-	VALCAL17	0=Neither 1=Mitral 2=Aortic 3=Both	Structural
Left Ventricular Diastolic Function Assessment	-	LVDFA17	0=Normal Diastolic Function 1=Indeterminate 2=Diastolic Dysfunction 3=Normal, determined by lab	Functional
Left Ventricular Diastolic Dysfunction Grading	LVDD grade	LVDDGR17	0=Normal 1=Grade I 2=Grade II 3=Grade III 4=Indeterminate 5=Normal, determined by lab	Functional

Echocardiography Variables for Analyses

As seen in the table above, there were a number of variables that were created after the scan data was collected. Some of these variables were evaluated by a central reviewer at the Echo Core Lab, and were included in the Echocardiography Addendum form (see page 19), while others were created in SAS at the Pittsburgh CC during the data freezing process. The echocardiography variables created at the Echo Core were

- *Aortic Regurgitation*
- *Mitral Regurgitation*
- *Tricuspid Regurgitation*
- *Pulmonic Regurgitation*
- *LV Wall Motion Abnormalities*
- *Valvular Calcification*
- *Estimated CVP*
- *Global Circumferential Strain mid LV*

The echocardiography variables created in SAS were computed from the TomTec results sheet. These variables required specific equations and multistep criteria as follows:

- *Pulmonary Artery Systolic Pressure (see Table 5)*
- *Cardiac Index (see Table 5)*
- *TDI E' Velocity (Average) (see Table 5)*
- *Left Ventricular Diastolic Function Assessment (see Figure 1)*
- *Left Ventricular Diastolic Dysfunction Grading (see Figure 2 and Table 6)*

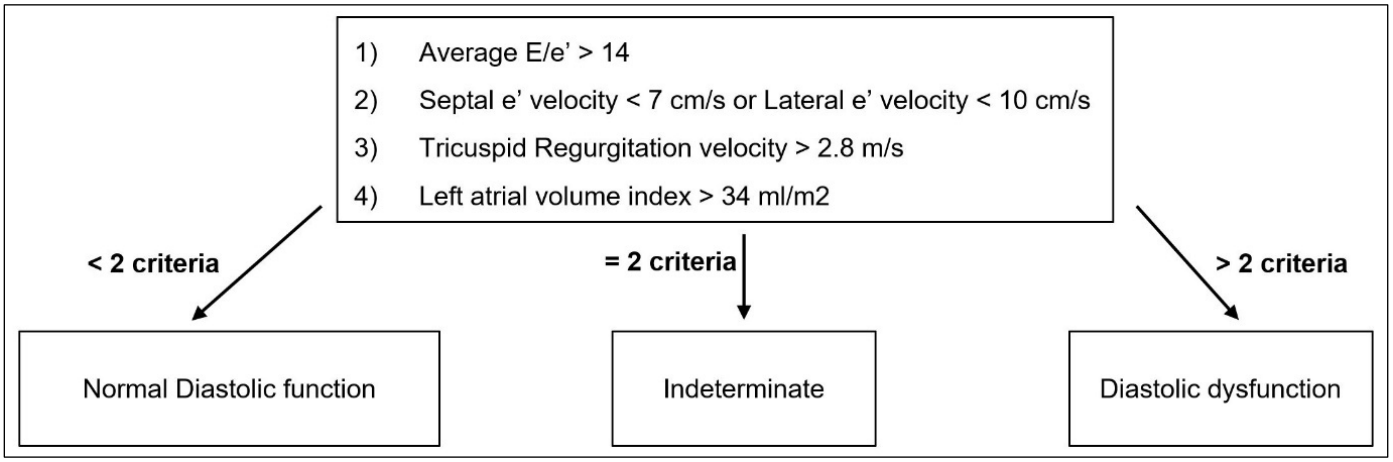
The following conditions were reasons of exclusion for the diastolic function assessments:

1. Valvular heart disease (Mitral stenosis, severe mitral regurgitation, mitral annular calcification, severe aortic stenosis, severe aortic regurgitation)
2. Atrial fibrillation
3. Atrioventricular Block and pacing
4. Heart transplantation
5. Prosthetic valve
6. Pericardial disease, moderate or severe pericardial effusion

Table 5: Equations for PAPs, CI, and E' (avg) [PASP17, CARDIND17, & TDIEVAVG17]

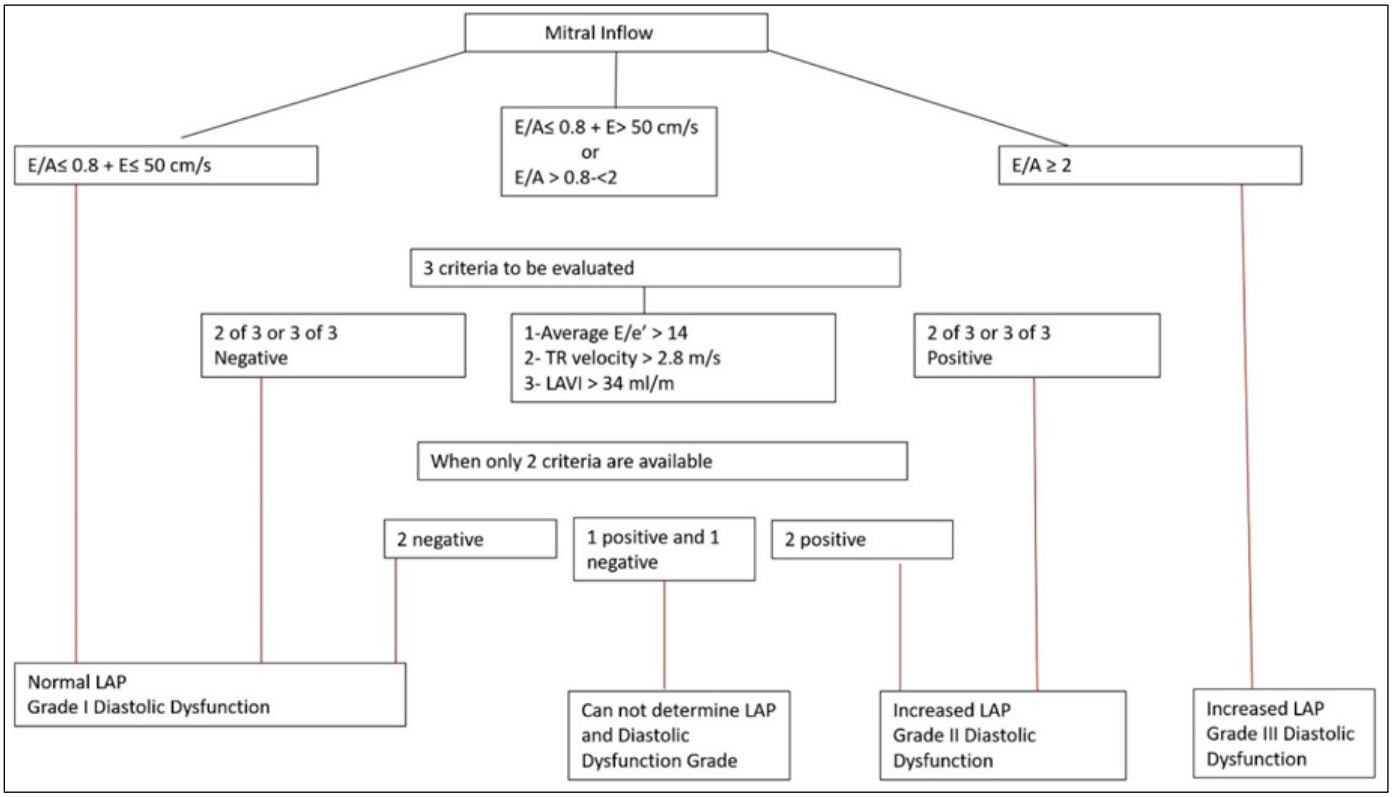
Pulmonary Artery Systolic Pressure	= (TR peak velocity (TR Vmax)^2 x 4) + Estimated CVP
Cardiac index (calculated)	= Stroke volume index x heart rate
TDI e' Velocity (average)	= [E'(s) + E'(l)] / 2

Figure 1: Parameters for Left Ventricular Diastolic Function Assessment (LVDFA17)



Note: This assessment was only conducted for participants with normal left ventricular ejection fraction (LVEF≥50%) [12,13]. All those with LVEF<50% were automatically categorized as "Diastolic Dysfunction."

Figure 2: Left Ventricular Diastolic Dysfunction Grading (LVDDGR17)



Note: This assessment was only conducted for participants with depressed left ventricular ejection fraction (LVEF <50%) and participants with normal LVEF who met >2 criteria in Figure 1 [4,5]. All others with normal LVEF and 2 or fewer criteria from Figure 1 were categorized as "Normal."

Table 6: Results Summary in Grades of Left Ventricular Diastolic Dysfunction (LVDDGR17)

	Normal	Grade I	Grade II	Grade III
LV Relaxation	Normal	Impaired	Impaired	Impaired
Left Atrial Pressure	Normal	Low or normal	Elevated	Elevated
Mitral E/A Ratio	≥0.8	≤0.8	>0.8 to <2	>2
Average E/e' Ratio	<10	<10	10-14	>14
Peak Tricuspid Regurgitation Velocity	<2.8	<2.8	>2.8	>2.8
Left Atrial Volume Index	Normal	Normal or increased	Increased	Increased

C. Data Cleaning Strategy

Echo Core Lab Data Cleaning Process

Based on the guidelines outlined in the Echo Acquisition manual, echocardiography images were effectively transmitted to the data stream system from a total of six distinct sites. Additionally, the Echo Core Lab successfully imported the aforementioned images to the TomTec Workstation.

Following the completion of the measurements and analysis, the TomTec result sheet was exported in CSV format. This action allows for the data to be stored and shared in a structured format. However, parameters that could not be exported in CSV format or were based on comments were manually entered into the data stream application form.

The strategy for cleaning echocardiography data occurred in two stages in terms of both echo image quality and protocol compliance. In stage one (before images were read), echocardiography scans were reviewed and scored for overall quality assessment by the Echo Core using the CRF. Images were scored per the following image quality criteria (expressed in the variable IMAGEQ17):

Echo image quality:

3 = Excellent – All images clearly captured, no artifacts seen

2 = Good – Slightly poor echo density and minimal artifact seen

1 = Unsatisfactory – Unclear endocardial boarder and multiple artifacts seen

In stage two (after images were read), echocardiography data was reviewed. At this stage, it was checked whether the images were recorded one by one in accordance with the protocol in the echo acquisition manual (expressed in the variable PROCOMP17).

Protocol compliance:

3 = Excellent – All images are captured according to study protocol

2 = Good – A few images are missing. However, all "must" variables are obtained

1 = Unsatisfactory –Several images are not captured and there are missing "must" variables

Using these variables, echo scans were reallocated into the two groups of full/complete and quick scan (meant to obtain an abbreviated list of parameters including minimum meaningful dataset, when the full scan was not possible to perform). Additionally, a flag variables was created to identify cases with unsatisfactory image quality or protocol compliance (QUALFLG17).

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DATA COLLECTION FORMS

 # = Variable excluded from public use datafile
~ A randomly generated ID will be provided that is different from the original ID
† This date is given in days since the initial baseline interview, which is day zero

A. Echocardiography Acquisition Form

Date Data Entered / Initials _____ Date Verified / Initials _____

ECHOCARDIOGRAPHY ACQUISITION FORM

***NEW FOR V17**

Study of Women's Health Across the Nation

SECTION A. GENERAL INFORMATION

AFFIX ID LABEL HERE

A1. RESPONDENT ID: **ARCHID~**

A2. SWAN STUDY VISIT # 17 **VISIT**

A3. FORM VERSION: 8/12/2021, 11/24/2021, 12/05/2022, 1/8/2024 **#FORM_ACQ**

A4. SCAN DATE: ____ ____ / ____ ____ / ____ ____ ____ ____ **SCAN_DAY†**
M M D D Y Y Y Y

A5. INTERVIEWER'S INITIALS: _____ _____ _____ **#INITS**

A6. SONOGRAPHER ID: _____ _____ _____ **#SONO_ID**

A.7. WAS THE ECHOCARDIOGRAM COMPLETED? **#ECHOCOMP**
NO 1
YES.....2 **A8**
YES, BUT ECHO LAB LOST.....3 **(version 1/2024)**

A7.1 WHY WAS THE ECHOCARDIOGRAM NOT COMPLETED? **#ENOTCOMP**

EQUIPMENT PROBLEM .....1 **END**
PARTICIPANT WAS UNABLE .....2 **END**
NOT ENOUGH TIME .....3 **END**
OTHER .....4 **END**
IF OTHER, SPECIFY **#EOTHSPEC** _____
REFUSED..... -7 **END**

A.8. WHICH ECHOCARDIOGRAM PROTOCOL WAS COMPLETED? **#ECHOPRO**
COMPLETE SCAN 1
QUICK SCAN.....2

SECTION B. BLOOD PRESSURE (versions 11/2021, 12/2022, 1/2024)

B1. WAS THE PARTICIPANT'S BLOOD PRESSURE MEASURED AT THE TIME OF THE ECHOCARDIOGRAM? **#BPECHO17**

NO.....1 **(B1.a)**
YES .....2 **(B2)**

B1.a. IF NO, SPECIFY REASON: ___**#NOBPSP17**_____ **(C1)**

B2. BLOOD PRESSURE (SYS/DIA) __**#SYSBP1**_ / _**#DIABP1**__ mmHg

SECTION C. ALERTS

C1. WAS THERE AN ALERT? **#ALERT**

NO.....1 **D1**
YES, INTERMEDIATE 2 **C1.a**
YES, URGENT.....3 **C1.a**
YES, IDENTIFIED BY CORE LAB 4 **C5** (12/2022, 1/2024)

C1.a. REASON FOR ALERT **#ALERTR** (versions 12/2022, 1/2024)

_____
_____
_____

C2. WERE ACTIONS TAKEN? **#ACTIONS**

NO.....1 **C3**
YES.....2

C2.a. WHAT ACTION(S) WERE TAKEN? (CHECK ALL THAT APPLY):

☐ Site physician was contacted **#ACTAKSP**
☐ Participant sent to the Emergency Department **#ACTAKED**
☐ Scan sent to Central Lab with request for clinical summary **#ACTAKCS**
☐ Clinical summary shared with Participant (and her physician, if applicable) **#ACTAKPT**
☐ Other **#ACTSPO** , specify **#ACTOTHSP**

_____

C3. DISPOSITION (CIRCLE ONE RESPONSE): **#DISPOSIT**

Participant went home after the clinic visit.....1
Participant was discharged to home from Emergency Department.....2
Participant was hospitalized.....3
Other.....4
If Other, specify **#DISOTH** _____

C4. ADDITIONAL COMMENTS: **#ECHOCOM17**

_____
_____
_____

CORE LAB ALERT: ANSWER C5 ONLY IF ALERT WAS IDENTIFIED BY CORE LAB (C1 ANSWERED AS 4)
C5. WAS THE CLINICAL SUMMARY SHARED WITH THE PARTICIPANT (AND HER PHYSICIAN, IF APPLICABLE)? **#CORELAB** **(versions 12/2022, 1/2024)**

NO……....1
YES……..2

C6. COMMENTS (REQUIRED IF C5 IS ANSWERED AS NO): **#CORELABA** **(versions 12/2022, 1/2024)**

_____

_____

_____

PLEASE NOTE THAT ALL DOCUMENTATION ASSOCIATED WITH THE ALERT SHOULD BE KEPT IN THE PARTICIPANT'S CHART.

SECTION D. DATE OF DATA TRANSMISSION N*

D1. DATE SCAN TRANSMITTED: ___ ___ / ___ ___ / ___ ___ ___ ___ **#SCTRAND17**
M M D D Y Y Y Y

***When transmitting scans with an alert to the ECHO Core Lab, select "US-Alert" as the Type in DataStream. This will flag the scan for the Core Lab and expedite review.**

B. Data Core Echocardiography Addendum