inHEART, SAS
Audrey Labeque
Quality and Regulatory Affairs Manager
IHU LIryc – Hôpital Xavier Arnozan-Avenue du Haut Lévêque
Pessac, 33600
France

February 29, 2024

Re: K231683
Trade/Device Name: inHEART Models
Regulation Number: 21 CFR 892.2050
Regulation Name: Medical image management and processing system
Regulatory Class: Class II
Product Code: QIH, LLZ
Dated: January 25, 2024
Received: January 25, 2024

Dear Audrey Labeque:

We have reviewed your section 510(k) premarket notification of intent to market the device referenced above and have determined the device is substantially equivalent (for the indications for use stated in the enclosure) to legally marketed predicate devices marketed in interstate commerce prior to May 28, 1976, the enactment date of the Medical Device Amendments, or to devices that have been reclassified in accordance with the provisions of the Federal Food, Drug, and Cosmetic Act (the Act) that do not require approval of a premarket approval application (PMA). You may, therefore, market the device, subject to the general controls provisions of the Act. Although this letter refers to your product as a device, please be aware that some cleared products may instead be combination products. The 510(k) Premarket Notification Database available at https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/pmn.cfm identifies combination product submissions. The general controls provisions of the Act include requirements for annual registration, listing of devices, good manufacturing practice, labeling, and prohibitions against misbranding and adulteration. Please note: CDRH does not evaluate information related to contract liability warranties. We remind you, however, that device labeling must be truthful and not misleading.

If your device is classified (see above) into either class II (Special Controls) or class III (PMA), it may be subject to additional controls. Existing major regulations affecting your device can be found in the Code of Federal Regulations, Title 21, Parts 800 to 898. In addition, FDA may publish further announcements concerning your device in the Federal Register.

Additional information about changes that may require a new premarket notification are provided in the FDA guidance documents entitled "Deciding When to Submit a 510(k) for a Change to an Existing Device" (https://www.fda.gov/media/99812/download) and "Deciding When to Submit a 510(k) for a Software Change to an Existing Device" (https://www.fda.gov/media/99785/download).

Your device is also subject to, among other requirements, the Quality System (QS) regulation (21 CFR Part 820), which includes, but is not limited to, 21 CFR 820.30, Design controls; 21 CFR 820.90, Nonconforming product; and 21 CFR 820.100, Corrective and preventive action. Please note that regardless of whether a change requires premarket review, the QS regulation requires device manufacturers to review and approve changes to device design and production (21 CFR 820.30 and 21 CFR 820.70) and document changes and approvals in the device master record (21 CFR 820.181).

Please be advised that FDA's issuance of a substantial equivalence determination does not mean that FDA has made a determination that your device complies with other requirements of the Act or any Federal statutes and regulations administered by other Federal agencies. You must comply with all the Act's requirements, including, but not limited to: registration and listing (21 CFR Part 807); labeling (21 CFR Part 801); medical device reporting (reporting of medical device-related adverse events) (21 CFR Part 803) for devices or postmarketing safety reporting (21 CFR Part 4, Subpart B) for combination products (see https://www.fda.gov/combination-products/guidance-regulatory-information/postmarketing-safety-reporting-combination-products); good manufacturing practice requirements as set forth in the quality systems (QS) regulation (21 CFR Part 820) for devices or current good manufacturing practices (21 CFR Part 4, Subpart A) for combination products; and, if applicable, the electronic product radiation control provisions (Sections 531-542 of the Act); 21 CFR Parts 1000-1050.

Also, please note the regulation entitled, "Misbranding by reference to premarket notification" (21 CFR 807.97). For questions regarding the reporting of adverse events under the MDR regulation (21 CFR Part 803), please go to https://www.fda.gov/medical-devices/medical-device-safety/medical-device-reporting-mdr-how-report-medical-device-problems.

For comprehensive regulatory information about medical devices and radiation-emitting products, including information about labeling regulations, please see Device Advice (https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance) and CDRH Learn (https://www.fda.gov/training-and-continuing-education/cdrh-learn). Additionally, you may contact the Division of Industry and Consumer Education (DICE) to ask a question about a specific regulatory topic. See the DICE website (https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance/contact-us-division-industry-and-consumer-education-dice) for more information or contact DICE by email (DICE@fda.hhs.gov) or phone (1-800-638-2041 or 301-796-7100).

Sincerely,

Jessica Lamb, Ph.D.
Assistant Director
Imaging Software Team
DHT8B: Division of Radiological Imaging
Devices and Electronic Products
OHT8: Office of Radiological Health
Office of Product Evaluation and Quality
Center for Devices and Radiological Health

Enclosure

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Food and Drug Administration

Indications for Use

Form Approved: OMB No. 0910-0120
Expiration Date: 06/30/2023
See PRA Statement below.

510(k) Number *(if known)*
K231683

Device Name
inHEART MODELS

Indications for Use *(Describe)*
inHEART MODELS comprises a suite of medical imaging software modules that are intended to provide qualified medical professionals with tools to aid them in reading, interpreting, reporting, and treatment planning. inHEART MODELS accepts DICOM compliant medical images acquired from a variety of imaging devices, including CT and MR*. The software is designed to be used by qualified medical professionals (including physicians, cardiologists, radiologists, and technicians) and the users are solely responsible for making all final patient management decisions.

* inHEART Models AI software module is indicated for adults only and is designed for CT images only.

CONTRAINDICATIONS:
This product is not intended for use with or for the primary diagnostic interpretation of Mammography images.

Type of Use *(Select one or both, as applicable)*

☒ Prescription Use (Part 21 CFR 801 Subpart D) ☐ Over-The-Counter Use (21 CFR 801 Subpart C)

CONTINUE ON A SEPARATE PAGE IF NEEDED.

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510(k) Summary

Submitter's Name:	inHEART, SAS
Address:	IHU Liryc – Hôpital Xavier Arnozan Avenue du Haut Lévêque 33600 Pessac, France
Contact: Telephone: Fax:	Audrey Labèque, Quality and Regulatory Affairs Manager +33 5 35 38 19 72 +33 5 57 10 28 86
Date:	February 29, 2024
Trade Name:	inHEART MODELS
Model No:	N/A
Regulation Description:	Medical Image Management and Processing System
Regulation number:	21 CFR 892.2050
Product Code:	Primary product code : QIH Secondary product code : LLZ
Regulatory Class:	Class II
Predicate Device:	K220727 – inHEART MODELS, inHEART

1. Device Description

inHEART MODELS is a suite of medical image processing software tools that enables 3D visualization and analysis of anatomical structures.

This software suite is composed of three software as a medical device components:

- inHEART MODELS AI: a medical image processing software for automatic 3D modelling, used to pre-process medical images (acquired only by CT devices).

  This software module uses a machine-learning based approach with the following characteristics:
  - Training dataset: 796 cases (3D CT original images and the segmentation masks) from previously manually performed segmentations (time period 2018-2022); origins of the data are public and private clinical and hospital institutions located in US (40%) and Europe (60%).
  - Training process: Machine learning algorithm (UNet) is trained applying data augmentation (including patch mirroring) and regularization (including Instance Normalization, Dropout, Data Augmentation, Weight Initialization, Leaky ReLU Activation) methods. Loss functions (soft dice loss and binary cross entropy) and optimization methods (stochastic gradient descent) are used during learning over a fixed number of 1000 epochs, each consisting of 250 iterations with a batch size of 2.
  - Data anonymized prior to its processing by inHEART team, therefore no personal data (gender, age, ethnicity) is exploitable. CT scanner manufacturers include Siemens (40%), GE Medical Systems (30%), Toshiba (10%) and other manufacturers (20%) among which Philips and Canon.
- inHEART MODELS Shaper: a standalone image processing software used to generate digital 3D models of the patient heart from medical images acquired by CT and/or MR devices and;
- inHEART MODELS Explorer: a web-based 3D visualization software that permits display, review, analysis, annotation and export of the cardiac 3D models generated from inHEART MODELS Shaper.

Specifically, these software modules read DICOM compatible pre-operative CT and MR images acquired by commercially available imaging devices. These images are then processed to generate 3D models of the anatomy to allow qualified medical professionals to display, review, analyze, annotate, interpret, export, and plan therapeutic interventions.

inHEART MODELS software suite also includes two non-device Medical Device Data Systems (MDDS) modules that are only intended to transfer, store and convert formats.

inHEART MODELS complies with the following standards:

- ISO, 14971 Third Edition 2019-12, Medical devices – Application of Risk Management to medical devices
- ISO, 15223-1 Third Edition 2016-11-01, Medical devices – Symbols to be used with information to be supplied by the manufacturer – Part 1: General requirements
- IEC, 62304 Edition 1.1 2015-06 CONSOLIDATED VERSION: Medical device software – Software life cycle processes
- IEC, 62366-1 Edition 1.1 2020-06 CONSOLIDATED VERSION: Medical devices – Part 1 : application of usability engineering to medical devices
- IEC, /TR 80002-1 Edition 1.0 2009-09, Medical device software – Part 1 : Guidance of the application of ISO 14971 to medical devices
- IEC, 82304-1 Edition 1.0 2016-10, Health software – Part 1 : General requirements for product safety
- IEC 81001-5-1 Edition 1.0 2021-12, Health software and health IT systems safety, effectiveness and security – Part 5-1 Security – Activities in the product life cycle

2. Indications for Use

inHEART MODELS comprises a suite of medical imaging software modules that are intended to provide qualified medical professionals with tools to aid them in reading, interpreting, reporting, and treatment planning. inHEART MODELS accepts DICOM compliant medical images acquired from a variety of imaging devices, including CT and MR*. The software is designed to be used by qualified medical professionals (including physicians, cardiologists, radiologists, and technicians) and the users are solely responsible for making all final patient management decisions.

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3. Comparison of technological characteristics with the predicate device

Table 1 Device Features and Technical Characteristic comparison matrix

Technological characteristics	inHEART MODELS (this submission)	inHEART MODELS (K220727) Predicate
Basic imaging tools		
Processing tools		
Filtering tools	Yes	Yes
Reformat tools	Yes	Yes
Meshing tools	Yes	Yes
Registration tools	Yes	Yes
Visualization tools		
2D viewer	Yes	Yes
3D viewer	Yes	Yes
Export capabilities	Yes	Yes
Reporting of results	Yes	Yes
Advanced imaging tools		
Segmentation	Yes (manually, semi-automated and fully automated some segmentations are automated using the new software module "inHEART Models AI")	Yes (manually and semi-automated)
Quantitative analysis	Yes	Yes
Product characteristics		
Mode of operation	Standalone and web-based software suite	Standalone and web-based software suite
Operating system	macOS for imaging processing software module Windows or macOS for web-based platform and compatible with following browser: Google Chrome, Apple Safari (for macOS), Microsoft Edge (for Windows)	macOS for imaging processing software module Windows or macOS for web-based platform and compatible with following browser: Google Chrome, Apple Safari (for macOS), Microsoft Edge (for Windows)
IT network	A standard internet connection is needed for the web-based platform.	A standard internet connection is needed for the web-based platform.
Input data	DICOM compliant medical images acquired from a variety of imaging devices including, CT, MR	DICOM compliant medical images acquired from a variety of imaging devices including, CT, MR

The following technological differences exist between the subject and predicate device:

- The predicate uses a combination of manual and semi-automated processing and segmentation. The proposed device uses fully automated reformatting (reslice tool) and segmentation steps using a new software module "inHEART MODELS AI", followed by review and additional manual and semi-automated processing and segmentation through existing and already cleared software module "inHEART MODELS Shaper".

The original processing and updated processing sequences have been validated to demonstrate that the outputs are substantially equivalent.

The indications for Use statement for the subject and predicate devices is similar.

4. Performance data and assessment

The following performance data were provided in support of the substantial equivalence determination:

- Software verification and validation testing were conducted on all inHEART MODELS software modules and documentation was provided as recommended by FDA's Guidance for Industry and FDA Staff, "*Guidance for the Content of Premarket Submissions for Software Contained in Medical Devices.*"

inHEART MODELS was considered as a "moderate" level of concern.

- In addition, accuracy of segmentations for inHEART MODELS was compared to ground truth and to predicate device inHEART MODELS (K220727). In this study, the ability of the new automated software module was assessed to perform initial segmentations of medical images that, in conjunction with predicate device, allow to produce results comparable to what is obtained using FDA-approved predicate device alone.
  The study consists in the following steps:
  1. Approval by external experts (radiologists) of segmentations previously obtained with the predicate device, that will constitute the Ground Truth (GT)
  2. Comparison of unprocessed outputs of the new automated software module results with the GT to establish the internal validation of the tool performance
  3. Comparison of new automated software module segmentations after their review and edition by expert users using predicate device with the GT validated in step 1 to establish substantial equivalence to the predicate and proposed device.

Details about this performance validation study:

- Testing dataset: 100 CT cases were randomly selected on the time period year 2023 to ensure independence of training/testing datasets; the sources are similar to the training dataset including new clients. In order to use this as a ground truth, two external experts evaluated the concordance of the manual segmentations for the task in which the use of this software is inscribed.
- Testing criteria: since the objective is to provide the expert segmenter with an initialization of the segmentation required for producing the 3D models, the

criteria used for performance are Dice coefficient (>0.9 for acceptance without manual correction), Average Symmetric Surface Distance (ASSD) (<5mm for acceptance without manual correction), a volumetric analysis of the produced model (<20 mL for acceptance without manual correction, <15mL absolute and <10% relative after correction for the main chambers). These thresholds are defined considering that the purpose of this module is not to replace manual expert segmentation but to accelerate its process. A subgroup analysis was performed on scanner manufacturers, region, CT quality, and different etiology information provided for the processing of the patient's case by our experts (including pathologies or implanted devices).

- Performance testing results:

The following table depict corresponding DICE and ASSD scores and volume quantification for each structure among the 100 cases of this study, computed between the revised segmentations made by experts based on AI results versus GT.

	DICE			ASSD			Volume diff. (mL)			Volume diff. (%)		
	Median	Mean	StdDev	Median	Mean	StdDev	Median	Mean	StdDev	Median	Mean	StdDev
Aorta	0.95	0.93	0.10	0.64	0.77	0.54	3.95	4.74	4.07	5%	8%	11%
Left Atrium	0.95	0.95	0.02	1.16	1.24	0.61	5.97	7.84	8.98	3%	5%	6%
Left Ventricle Endocardium	0.97	0.97	0.02	0.97	0.97	0.02	4.92	6.36	5.32	2%	3%	3%
LV Epicardium	0.97	0.97	0.01	0.71	0.76	0.30	7.22	10.10	9.96	2%	3%	2%
Pulmonary Artery Trunk	0.93	0.91	0.07	1.41	2.02	2.15	7.38	10.84	11.38	9%	14%	20%
Right Atrium & Inf. Vena Cava	0.93	0.92	0.04	1.17	1.30	0.57	7.28	9.87	10.12	4%	6%	6%
Right Ventricle Endocardium	0.92	0.91	0.05	1.22	1.25	0.56	9.89	14.99	14.98	7%	11%	12%
RV Epicardium	0.94	0.93	0.03	0.95	1.06	0.45	6.42	8.67	8.07	4%	4%	4%

Average Dice score is 0.94, average ASSD is 1.17mm, average volume variations is 9,18mL and 7%.

All validation criteria were met, and the performance evaluation study demonstrated that output segmentations and measurements on these segmentations for inHEART MODELS were substantially equivalent to previously cleared legally marketed software devices.

4. Conclusion

No new safety or efficacy issues were introduced by inHEART MODELS compared to the predicate device.
inHEART MODELS has similar intended use, similar labeling, similar indications for use and clinical application tools as those of the cleared predicate device inHEART MODELS (K220727).
Furthermore, performance data demonstrate that the functionality, output and clinical usage of inHEART MODELS is substantially equivalent to the predicate device.