Clinical Features Distinguishing Diabetic Retinopathy Severity Using Artificial Intelligence

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BACKGROUND

- 37.2 million Americans (1 in 10) have diabetes
- 1 in 29 diabetics suffer from diabetic retinopathy
- Nearly 50% of diabetics have undetected diabetic retinopathy
- Features of diabetic retinopathy: microaneurysms, hemorrhages, cotton wool spots, exudates, neovascularization
- Non-proliferative diabetic retinopathy (NPDR): Mild, Moderate, Severe
  - No neovascularization
  - Mild: at least one microaneurysm or dot-blot hemorrhage
  - Moderate: at least one microaneurysm or dot-blot hemorrhage in one to three quadrants with at least one exudate, cotton wool spot, or venous beading
  - Severe: at least one microaneurysm in all four quadrants with at least two quadrants of venous beading and one or more quadrant of intraretinal microvascular abnormalities
- Proliferative diabetic retinopathy (PDR): most damaging form of diabetic retinopathy
  - Neovascularization or vitreous/ pre-retinal hemorrhage
 - New vessel growth leads to increased ocular pressure and damage to the optic nerve
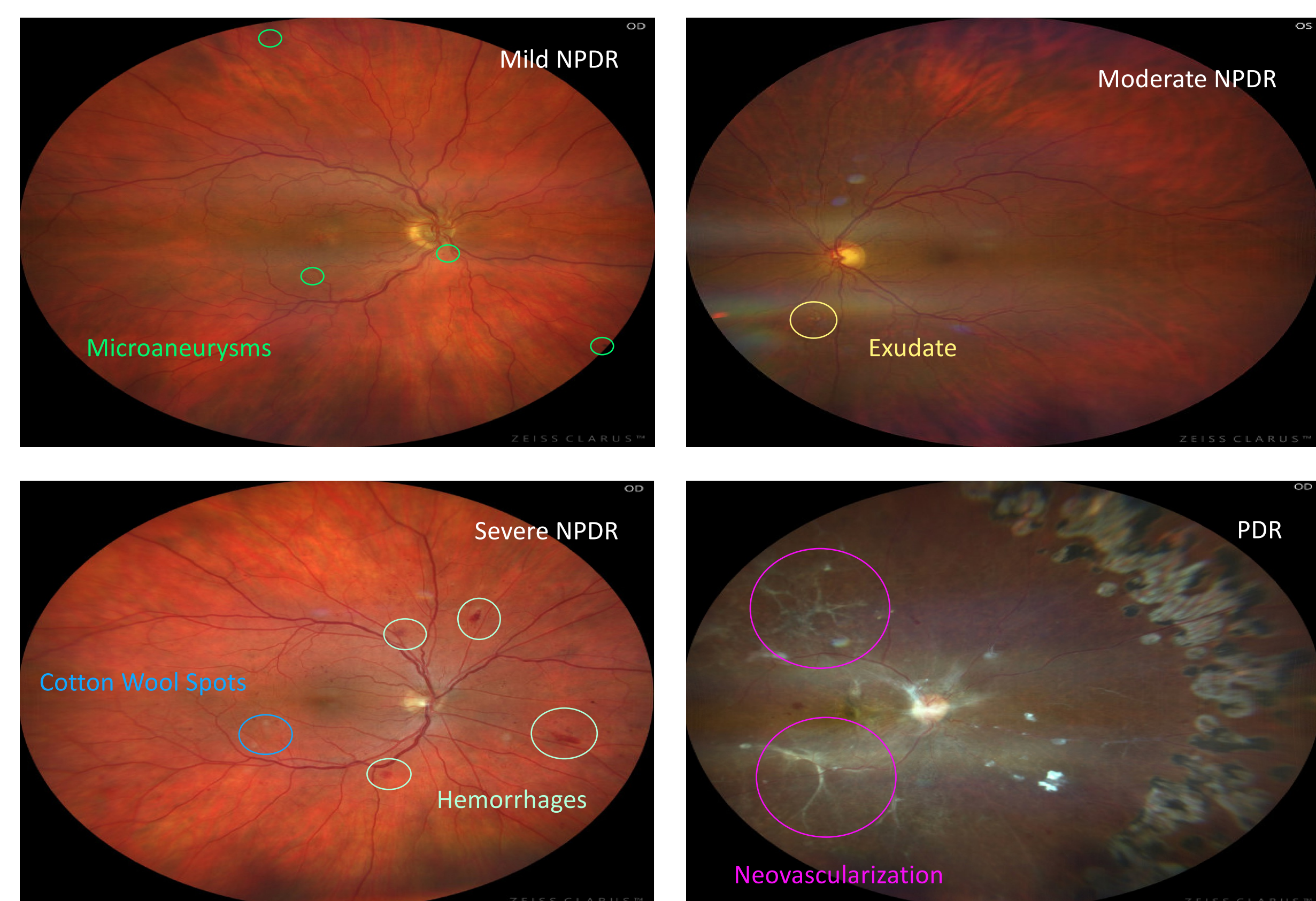
OBJECTIVE

- The aim of this study was to categorize patients based upon diabetic-related diagnoses and then manually annotate retinal images per patient to create a dataset of common diabetic retinopathy features
- The coordinates obtained through image annotation will allow us to train an artificial intelligence system to diagnose diabetic retinopathy
- We hypothesize that increasing the rate and ease of diagnosing diabetic retinopathy by introducing artificial intelligence-based methods in primary medical clinics will increase the long-term preservation of ocular health in diabetic patients
- Our artificial intelligence-based methods will allow for the early diagnosis of diabetic retinopathy in clinics such as primary care, pediatrics, and endocrinology
- Early diagnosis of diabetic retinopathy allows the patient to begin treatment immediately in order to preserve ocular health and decrease the visual effects of diabetes

MATERIALS AND METHODS

IU Health Records → Patient Demographic Categorization → Retinal Image Annotations via VGG Image Annotator Application → Coordinates of Diabetic Retinopathy Features
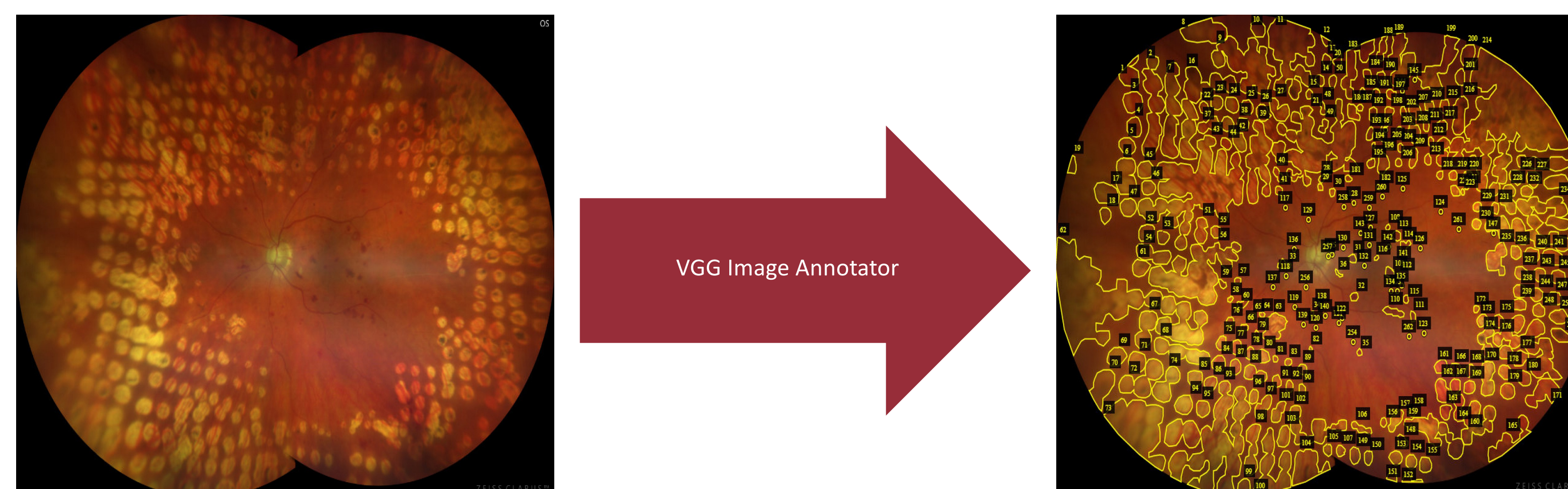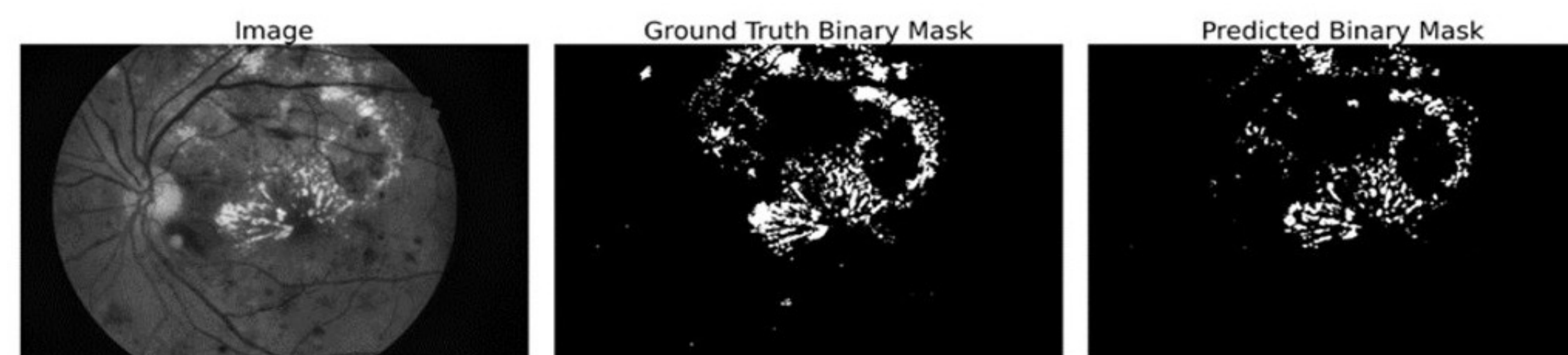

Manual annotations of retinal images were performed using the VGG Image Annotator application, creating the image seen above on the right. It is the coordinates of these annotations that will be used to train an artificial intelligence system to detect features of diabetic retinopathy

RESULTS

Average A1c of All Diabetic Patients	Average A1c without DR	Average A1c with DR	Average A1c Mild NPDR	Average A1c Moderate NPDR	Average A1c Severe NPDR	Average A1c PDR
7.95% (SD = 0.0199)	7.20% (SD = 0.0174)	8.16% (SD = 0.0174)	7.93% (SD = 0.0137)	8.09% (SD = 0.0195)	8.64% (SD = 0.0176)	7.98% (SD = 0.0175)

- Average HbA1c of all diabetic patients = 7.95%
- Average HbA1c of all diabetics without diabetic retinopathy = 7.20% ($p < 0.007$)
- Average HbA1c of all diabetics with any severity of diabetic retinopathy = 8.16% ($p < 0.32$)
- A significant statistical difference was found between the HbA1c values of diabetics with any severity of diabetic retinopathy and diabetics without diabetic retinopathy ($p < 0.002$)

- With the manual annotations performed through the VGG Image Annotator application, we created the ground truth binary mask of the retinal image
- The predicted binary mask shown above is an example of the annotations created through artificial intelligence-based methods after training with our manual annotations
- The annotations and coordinates created through the VGG Image Annotator application were successful in allowing for artificial intelligence to annotate retinal images for common features of diabetic retinopathy
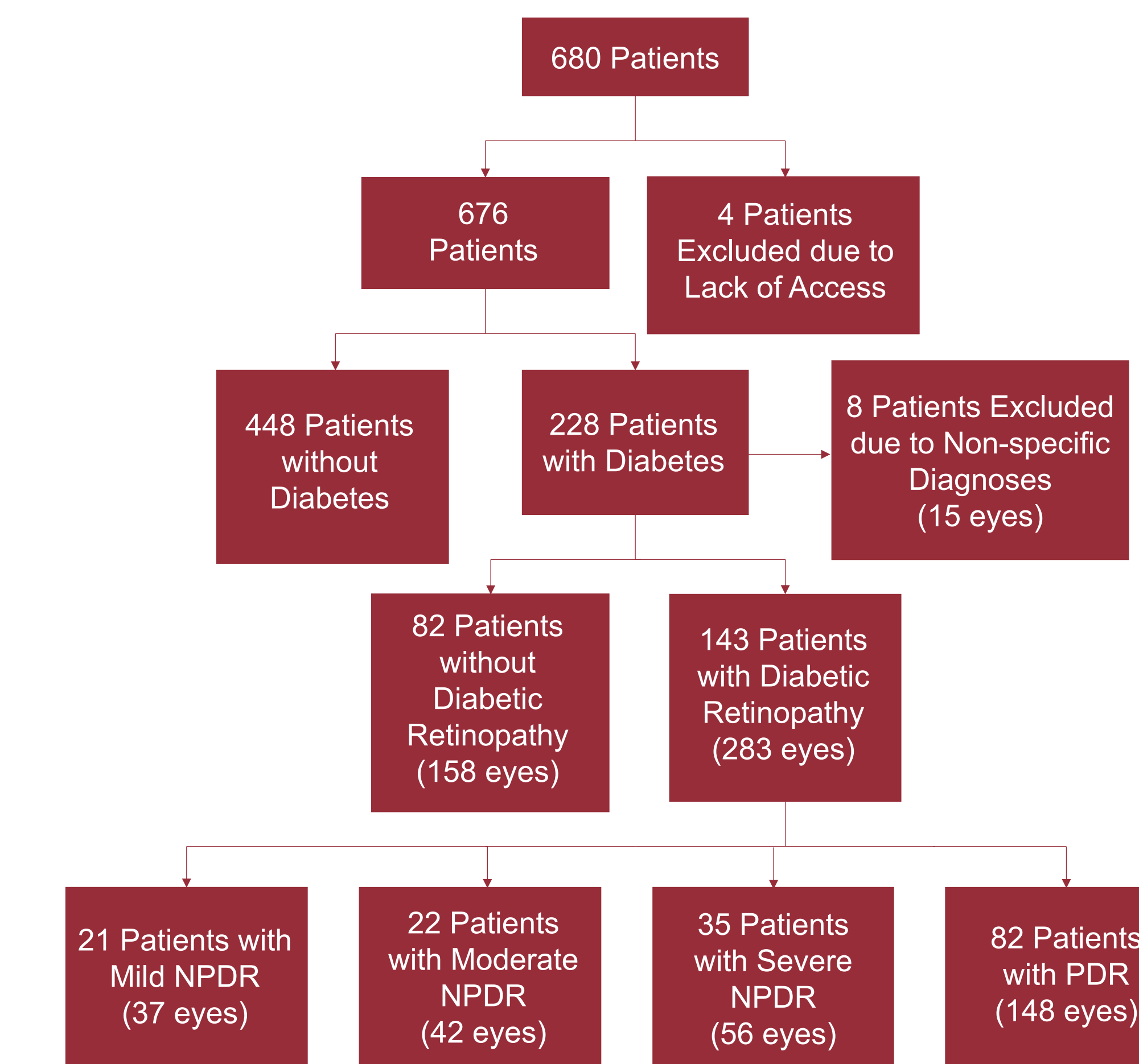
Using IU Health records for each of the 680 patients in this study, patient demographics as such were created. A total of 228 patients (33.7%) had diabetes and 143 patients (62.7% of diabetics) had at least one eye with diabetic retinopathy. 82 patients had diabetes with no retinopathy, 21 patients had mild NPDR, 22 patients had moderate NPDR, 35 patients had severe NPDR, and 82 patients had PDR.

CONCLUSIONS

- 62.7% of the diabetics in this study had at least one eye with diagnosed diabetic retinopathy, compared to the 1 in 29 diabetic Americans that suffer from diabetic retinopathy
- Significant statistical differences were found between the average HbA1c values of all diabetic patients compared to diabetics without diabetic retinopathy and between diabetics with any severity of diabetic retinopathy and diabetics without diabetic retinopathy
- Manual annotations via the VGG Image Annotator application proved to be effective in creating a dataset of coordinates to train an artificial intelligence system in the future

FUTURE DIRECTIONS

1. Train artificial intelligence system using the dataset of coordinates and HbA1c values from this study to detect common features of diabetic retinopathy
2. Incorporate artificial intelligence system linked with retinal imaging in primary clinical settings to increase the detection rate of diabetic retinopathy

ACKNOWLEDGEMENTS