Linking Medical Records to an Expert System

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This presentation will be done using the IMR-Entry (Intelligent Medical Record Entry) system. IMR-Entry is a software program developed as a front-end to our diagnostic consultant software MEDAS (Medical Emergency Decision Assistance System).

MEDAS (the Medical Emergency Diagnostic Assistance System) is a diagnostic consultant system using a multimembership Bayesian design for its inference engine and relational database technology for its knowledge base maintenance. Research on MEDAS began at the University of Southern California and the Institute of Critical Care in the mid 1970's with support from NASA and NSF. The MEDAS project moved to Chicago in 1982; its current progress is due to collaboration between Illinois Institute of Technology, The Chicago Medical School, Lake Forest College and NASA at KSC. We acknowledge the support provided by Dr. Daniel Woodard, Dr. Paul Buchanan and Dr. Ronald White.

MEDAS DISORDER PATTERN

```
Dec. 01, 1988           <<DISORDER PATTERN SYSTEM>>              Screen No.
8: 45: 36 AM          Developed by UHS/CMS Computer Center         MED S20


Disorder #12            Name: PULMONARY THROMBOEMBOLISM         # OF F: 75
(OR STOP)           Category: RESPIRATORY                    SORT ID: Post+
                 Date Created: 02/13/87
              Prevalence Rate: 0.07

                                                            Post.    Post
                                                            When +   When -
      F#        Feature Name                    P     Pbar
  1)  738   V/P LUNG SCAN: MMATCH VENT & (+) IPG  .949  .050  .588   .004
  2)  622   ANGIO: PULMONARY PERFUSION DEFECT     .899  .050  .575   .008
  3)  750   ECG - S1-Q3-T3 PATTERN                .100  .009  .455   .064
  4)  643   CXR: PULMONARY INFLITRATE UNILATERAL  .200  .029  .342   .058
  5)  174   S/O DEEP VEIN THROMBOPHLEBITIS        .300  .100  .184   .055
  6)  338   M.S. DEEP MUSCULAR TENDERNESS         .300  .100  .184   .055
  7)  485   PVS PITTING EDEMA UNILATERAL          .300  .100  .184   .055
  8)  630   V/P LUNG SCAN: EMBOLISM               .600  .200  .184   .036
  9)  747   H/O DEEP VEIN THROMBOSIS              .300  .100  .184   .055
 10)  638   CXR: ATELECTASIS                      .050  .019  .165   .068
 11) 1179   CXR PLEURAL EFFUSION UNILATERAL       .300  .119  .159   .056


      1) Look   2) Create   3) Delete   4) Change prob   5) Sort option   6) Exit

              Please select 1, 2, 3, 4, 5, or 6 >
```

This screen demonstrates the disorder pattern for Pulmonary Thromboembolism. Since the purpose of an expert system is to derive a hypothesis, its communication vocabulary is limited to features used by its knowledge base. Recognizing this problem our team in Chicago, for the last five years, has been working on the development of a comprehensive problem based medical record entry system which could handshake with an expert system while creating an electronic medical record at the same time.

IMR-E is a computer based patient record that serves as a " front end " to the expert system MEDAS. IMR-E is a graphically oriented comprehensive medical record. We demonstrate the program's major components in the following article:

IMR-Entry requires the provider to identify themselves before he or she is allowed to use the system. This Identification is used to tag all of the data created for the given session by the entry person's identification.
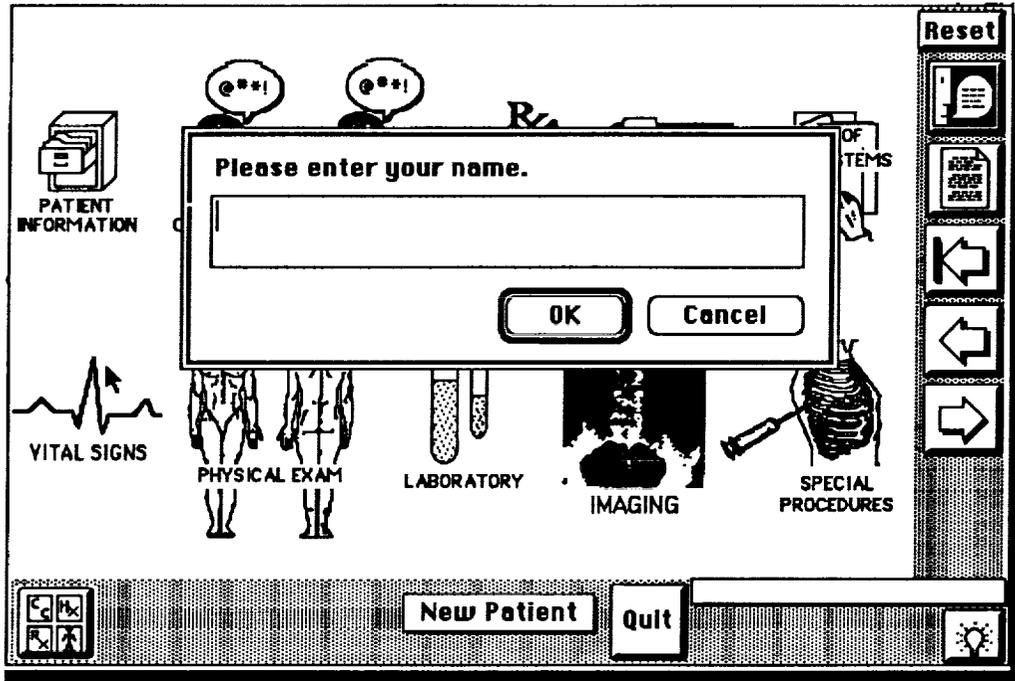
The following screen will appear by clicking on the Patient Information icon:
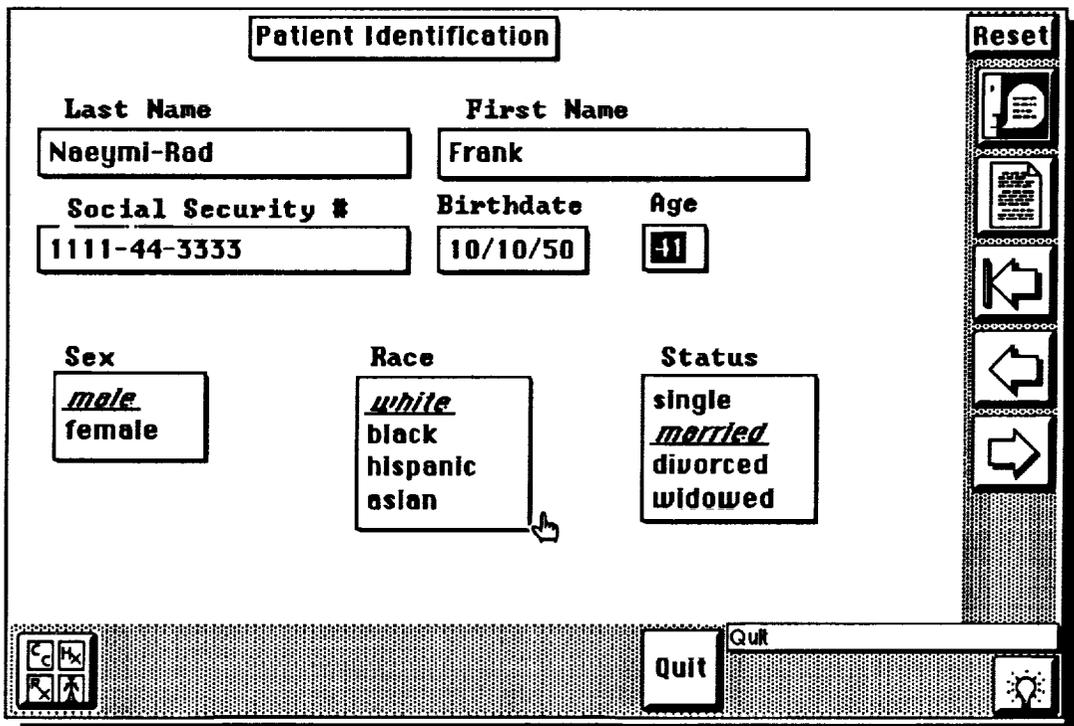
The patient selection screen can be integrated with any in-place demographics screen to eliminate the duplication of entry.

By clicking on the icon ⊞ the user will return to the following screen.
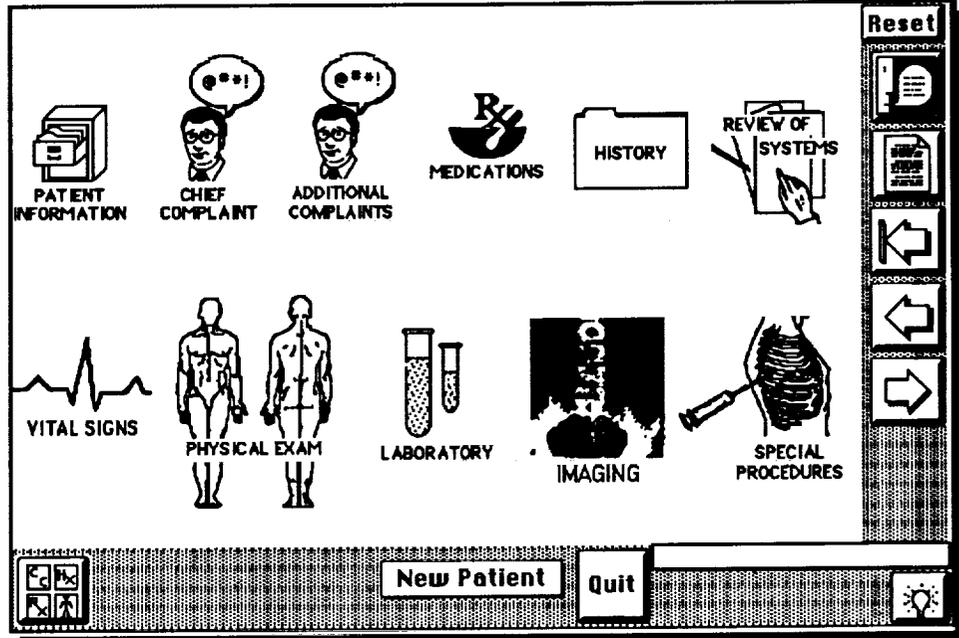
As you can see this is comprehensive and covers all of the sections for the physician's entry. The navigational icons were designed to aid the physician at each step of entry.

By clicking on the icon ☺ CHIEF COMPLAINT , the following screen appears:
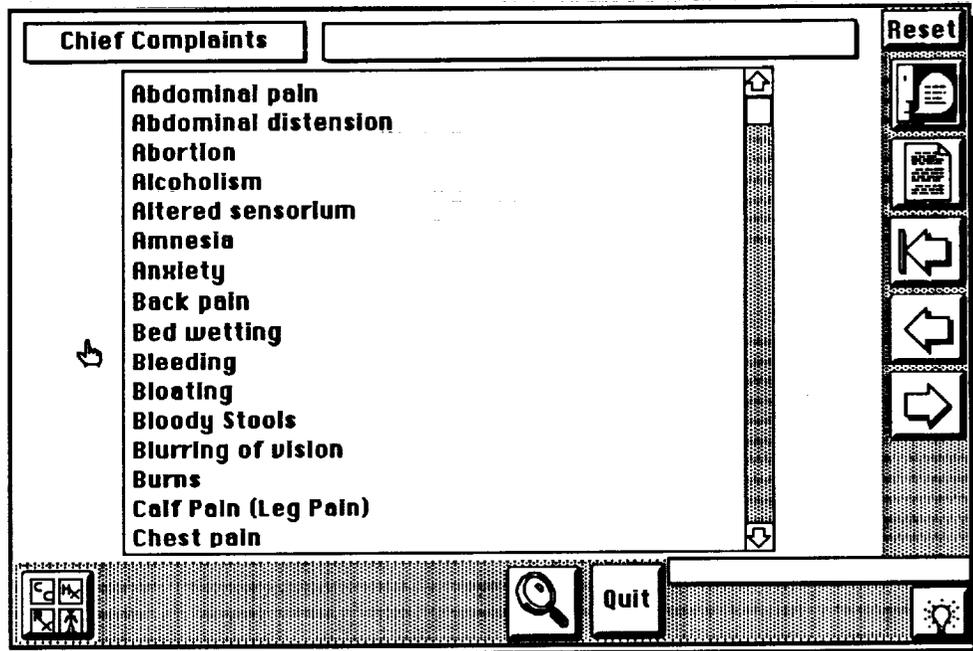
There are 95 complete complaint programs. Each program allows the physician to custom create a paragraph for a given complaint by using the computer mouse. Each program manages between 20 to 50 objects which are displayed on 3 to 5 screens.

This is the first screen for Abdominal Pain Chief Complaint. We can select the appropriate options by simply clicking on them.

```
┌─────────────────────────────────────────────────────────────────┐
│                    Abdominal Pain                        Reset    │
│  ┌────────┐  ┌──────────┐        ┌──────────┐                     │
│  │ Onset  │  │ Duration │        │ Pattern  │            [icon]   │
│  │ acute  │  │12│minutes │        │intermittent│                   │
│  │ sudden │  │  │ hours  │        │ persistent │          [icon]   │
│  │ gradual│  │  │ days   │        │ episodic │                     │
│  │variable│  │  │ weeks  │        └──────────┘          ◄─        │
│  └────────┘  │  │ months │                                         │
│              │  │ years  │                               ◄─        │
│  ┌────────┐  └──┴────────┘                                         │
│  │ Course │  ┌────────────┐      ┌──────────────┐        ─►       │
│  │increasing│ │  Location  │      │  Radiation   │                 │
│  │decreasing│ │right upper quadrant│ │left shoulder │               │
│  │constant  │ │left upper quadrant │ │back          │               │
│  │recurrent │ │epigastrium         │ │left flank    │               │
│  └────────┘  │periumbelical area  │ │right flank   │               │
│              │right lower quadrant│ │epigastrium   │               │
│              │left lower quadrant │ │right upper quadrant│          │
│              │suprapubic area     │ │left upper quadrant │          │
│              └────────────────────┘ └────────────────────┘         │
│                              A typical episode lasts how long?     │
└─────────────────────────────────────────────────────────────────┘
```

By clicking on the [⟹] we get the second screen for Abdominal Pain.

```
┌─────────────────────────────────────────────────────────────────┐
│                    Abdominal Pain                        Reset    │
│  ┌──────────────────────────┐  ┌──────────────────┐               │
│  │     Aggravated By        │  │   Relieved By    │      [icon]   │
│  │meals (2 to 4 hours after eating)│ │nothing         │             │
│  │lying down                │  │antacids          │      [icon]   │
│  │coughing                  │  │eating            │               │
│  │breathing                 │  │fasting           │       ◄─      │
│  │standing                  │  │vomiting          │               │
│  │walking                   │  │belching          │       ◄─      │
│  └──────────────────────────┘  └──────────────────┘               │
│  ┌────────────────────┐  ┌────────────┐                 ─►        │
│  │  Characterized As  │  │  Severity  │                           │
│  │burning             │  │mild        │                           │
│  │sharp               │  │moderate    │                           │
│  │stabbing            │  │severe      │                           │
│  │crampy              │  └────────────┘                           │
│  │colicky             │  ┌──────────────────────┐                 │
│  │a dull ache         │  │  Previous Evaluations │                │
│  │a pressure sensation│  │barium enema          │                 │
│  └────────────────────┘  │upper gastrointestinal H-ray│            │
│                          │proctoscopy           │                 │
│                          └──────────────────────┘                 │
└─────────────────────────────────────────────────────────────────┘
```

We can review text generated to this point by clicking on the icon

Abdominal Pain

Reset

Aggravated By

nothing
meals (1/2 to 1 hour after eating)
meals (2 to 4 hours after eating)

Relieved By

nothing
antacids
eating

The onset of the abdominal pain has been sudden and has been occurring for 12 hours. The pattern of the abdominal pain has been persistent. It's course has been increasing. The abdominal pain is located in the right lower quadrant with radiation to the left flank and left lower quadrant. It is aggravated by coughing, standing and walking while relief is obtained by nothing. The abdominal pain is characterized as sharp and stabbing. The severity of t[**OK**]

colicky
a dull ache
a pressure sensation

Previous Evaluations

barium enema
upper gastrointestinal X-ray
proctoscopy

The last screen for this complaint will appear by clicking on the icon

Abdominal Pain

Reset

Associated With

chest pain
constipation
dark urine
diarrhea
dysuria
fever
heartburn
hematemesis
hematuria
jaundice
melena
nausea
passing worms
pica
use of alcohol

Not Associated With

abdominal distension
amenorrhea
anorexia
bloating
bloody stools
bone pain
bulky stools
chest pain
constipation
dark urine
diarrhea
dysuria
fever
heartburn
hematemesis

When we continue clicking on the ⬜➡ we move to the Additional Complaints Screen.

Additional Complaints	abdominal pain	Reset

Testicular Pain
Tinnitus (Ringing in the Ears)
Unconsciousness
Urethral Discharge
Urinary Frequency (polyuria)
Urinary Incontinence
Vaginal Bleeding
Visual Disturbance
Visual Loss
Voice Changes
Vomiting
Weight Gain
Weight Loss
Wheezing
☐

Quit

Details on Associated & Additional Complaints	Reset

Fever
Nausea
Vomiting

To Medications

Quit

After selecting additional complaints, the system displays all the appropriate complaints that it has programmed for you. We could describe these complaints in more detail.

By selecting HISTORY folder `HISTORY` we can enter all of the history information.
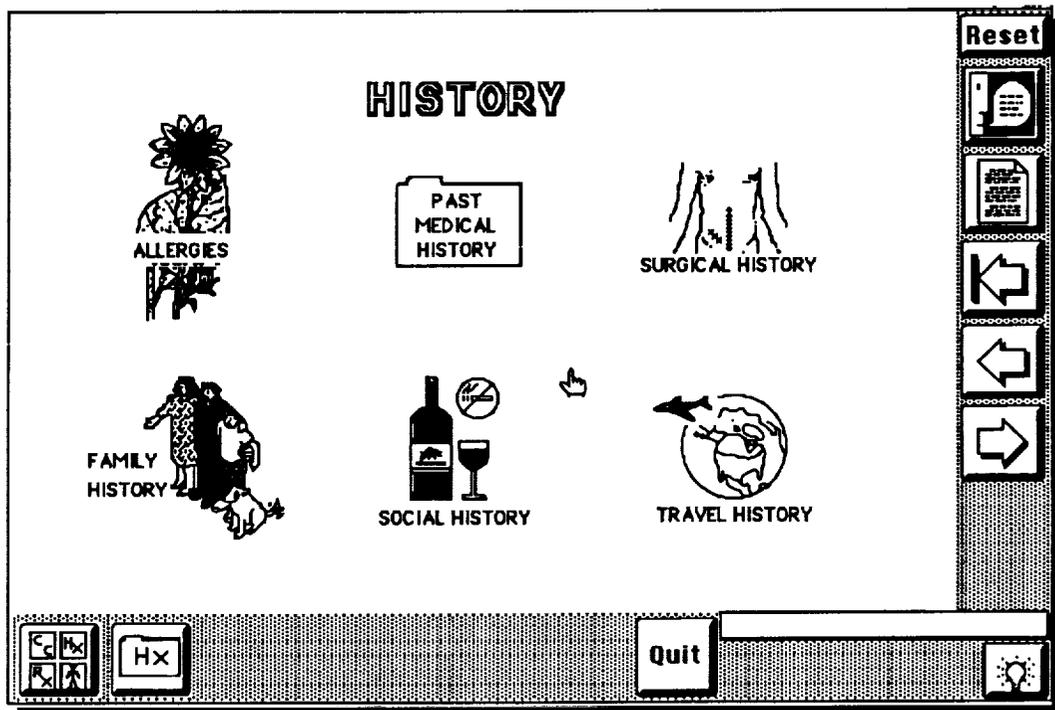
We must note that the Travel History is incomplete since does not include space travel history.

By selecting the PAST MEDICAL HISTORY Folder `PAST MEDICAL HISTORY` we get to the next screen.
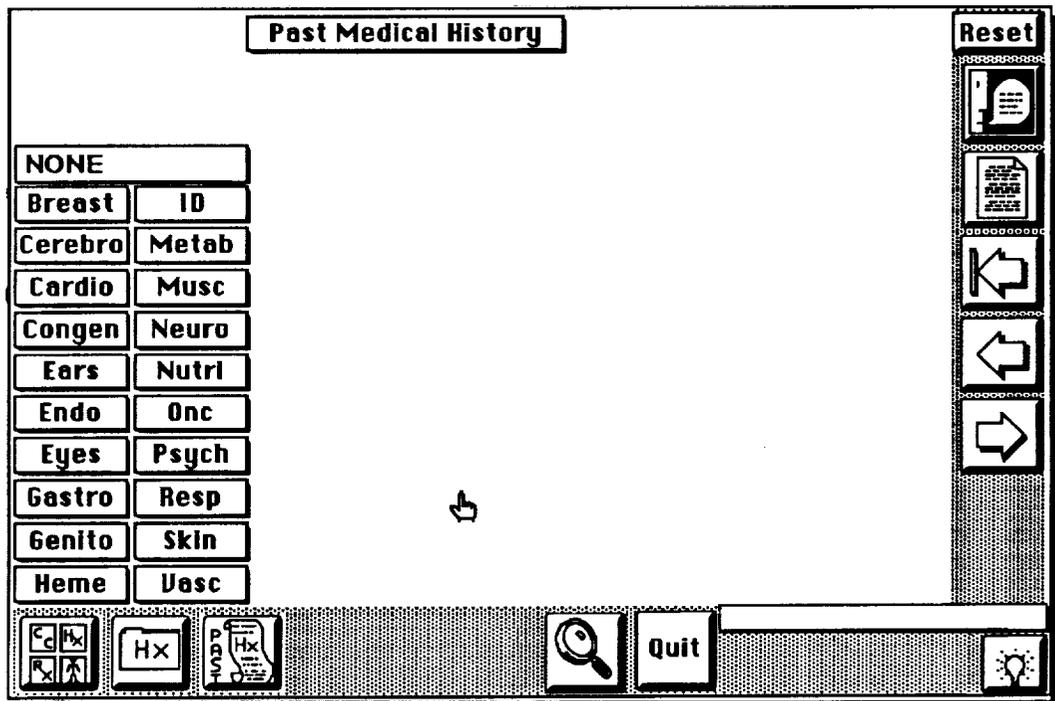
Please note: as the mouse 🖱 moves over the Icons, the dialog window on the lower right displays the function of the icon.

By clicking the text [icon] icon system displays the current status of the final electronic report.
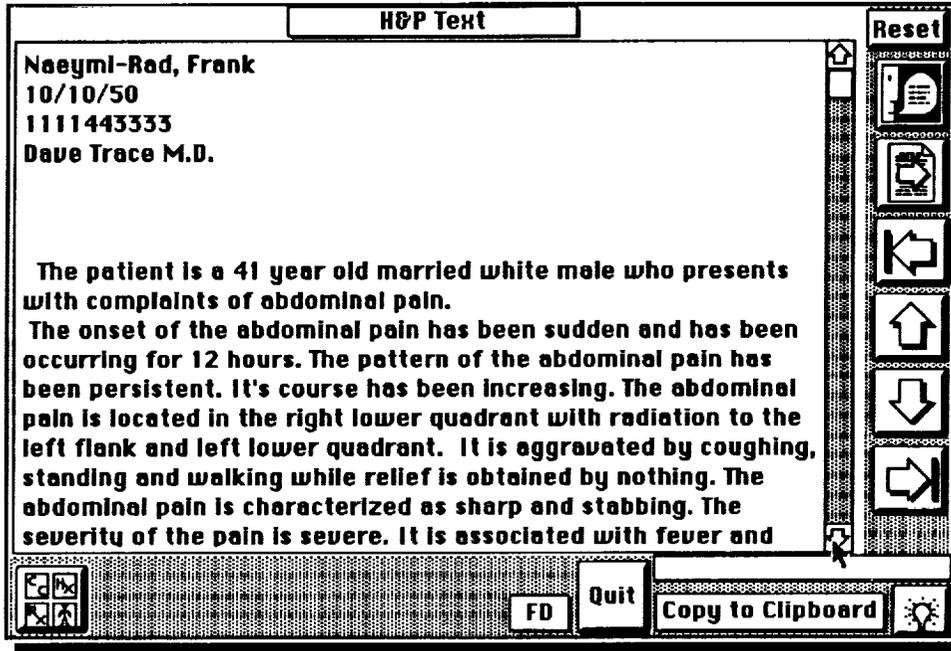
```
┌─────────────────── H&P Text ───────────────────┐  ┌──────┐
│                                              ⇧  │  │Reset │
│  Naeymi-Rad, Frank                              │  ├──────┤
│  10/10/50                                       │  │ 📄   │
│  1111443333                                     │  ├──────┤
│  Dave Trace M.D.                                │  │ 📄→  │
│                                                 │  ├──────┤
│                                                 │  │ ⇦    │
│   The patient is a 41 year old married white    │  ├──────┤
│  male who presents                              │  │ ⇧    │
│  with complaints of abdominal pain.             │  ├──────┤
│  The onset of the abdominal pain has been       │  │ ⇩    │
│  sudden and has been                            │  ├──────┤
│  occurring for 12 hours. The pattern of the     │  │ ⇨    │
│  abdominal pain has                             │  │      │
│  been persistent. It's course has been          │  │      │
│  increasing. The abdominal                      │  │      │
│  pain is located in the right lower quadrant    │  │      │
│  with radiation to the                          │  │      │
│  left flank and left lower quadrant.  It is     │  │      │
│  aggravated by coughing,                        │  │      │
│  standing and walking while relief is obtained  │  │      │
│  by nothing. The                                │  │      │
│  abdominal pain is characterized as sharp and   │  │      │
│  stabbing. The                                  │  │      │
│  severity of the pain is severe. It is          │  │      │
│  associated with fever and                   ⇩  │  │      │
├──────────────────────────────┬──────┬──────────┤  └──────┘
│ [icons]                      │  FD  │ Quit  Copy to Clipboard  ☼
└──────────────────────────────┴──────┴──────────┘
```

Note: the first paragraph does not have any information about significant past medical or surgical history.

We can go back to where the report generation was launched from by clicking this [icon] icon. by selecting the Gastrointestinal section and identifying the history to the system as significant to the present illness.
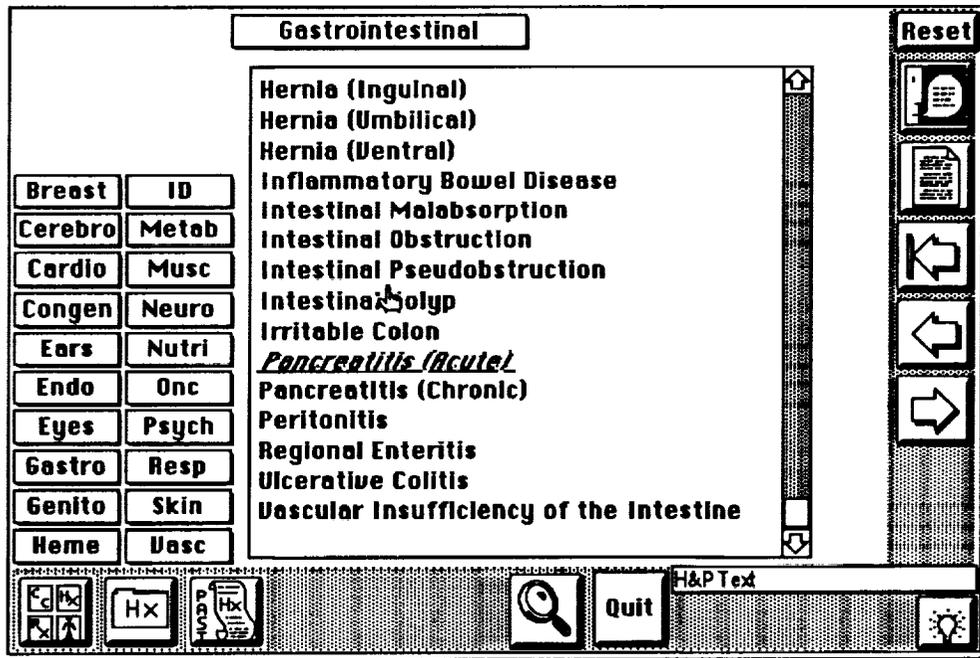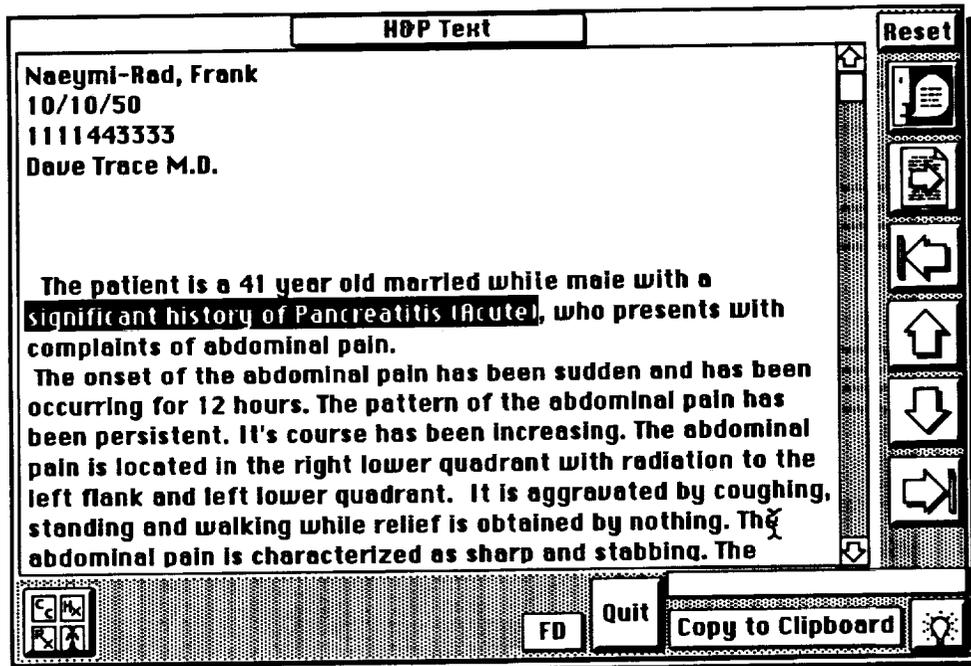
```
┌─────────── Gastrointestinal ───────────┐  ┌──────┐
│                                      ⇧  │  │Reset │
│            Hernia (Inguinal)            │  ├──────┤
│            Hernia (Umbilical)           │  │ 📄   │
│            Hernia (Ventral)             │  ├──────┤
│ ┌──────┐┌──────┐ Inflammatory Bowel     │  │ 📄   │
│ │Breast││ ID   │ Disease                │  ├──────┤
│ ├──────┤├──────┤ Intestinal Malabsorption│ │ ⇦    │
│ │Cerebro││Metab│ Intestinal Obstruction │  ├──────┤
│ ├──────┤├──────┤ Intestinal Pseudobstruction│ ⇧  │
│ │Cardio││Musc  │ Intestinal Polyp       │  ├──────┤
│ ├──────┤├──────┤ Irritable Colon        │  │ ⇨    │
│ │Congen││Neuro │ Pancreatitis (Acute)   │  │      │
│ ├──────┤├──────┤ Pancreatitis (Chronic) │  │      │
│ │Ears  ││Nutri │ Peritonitis            │  │      │
│ ├──────┤├──────┤ Regional Enteritis     │  │      │
│ │Endo  ││Onc   │ Ulcerative Colitis     │  │      │
│ ├──────┤├──────┤ Vascular Insufficiency │  │      │
│ │Eyes  ││Psych │ of the Intestine       │  │      │
│ ├──────┤├──────┤                        │  │      │
│ │Gastro││Resp  │                        │  │      │
│ ├──────┤├──────┤                     ⇩  │  │      │
│ │Genito││Skin  │                        │  └──────┘
│ ├──────┤├──────┤                        │
│ │Heme  ││Vasc  │                        │
│ └──────┘└──────┘              H&P Text  │
├──────────────────────────────┬──────┬──┤
│ [icons] [Hx] [Hx]        🔍  │ Quit │  ☼
└──────────────────────────────┴──────┴──┘
```
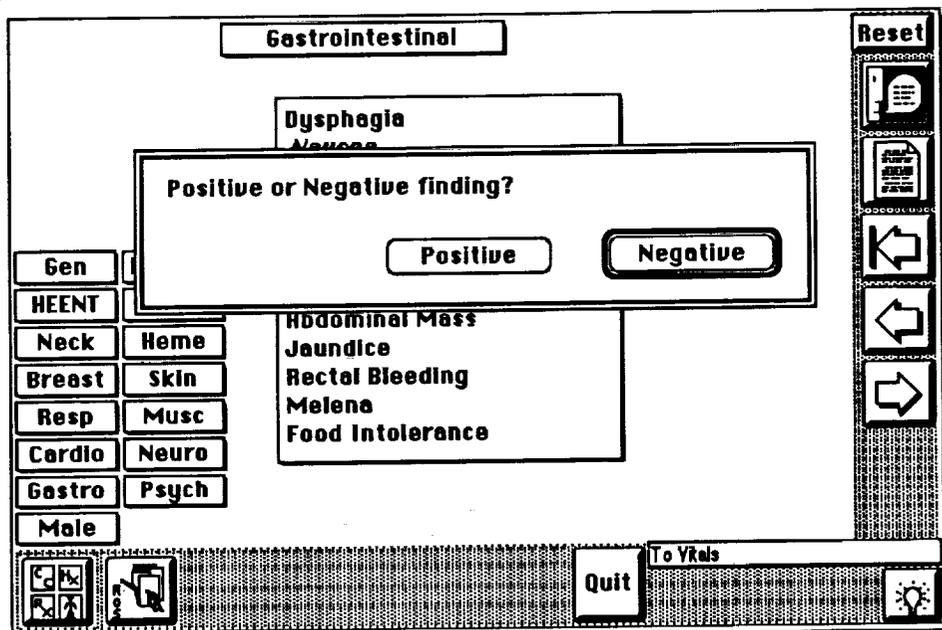
When clicking the text ![icon] icon, the system displays the current status of the final electronic report with the significant history within the first paragraph.

```
┌─────────────────────────────────────────────────┐ ┌──────┐
│                    H&P Text                       │ │Reset │
│ ┌───────────────────────────────────────────┐ ⬆ │ ├──────┤
│ │ Naeymi-Rad, Frank                          │   │ │  📄  │
│ │ 10/10/50                                    │   │ ├──────┤
│ │ 1111443333                                  │   │ │  📑  │
│ │ Dave Trace M.D.                             │   │ ├──────┤
│ │                                             │   │ │  ⬅  │
│ │                                             │   │ ├──────┤
│ │   The patient is a 41 year old married      │   │ │  ⬆  │
│ │ white male with a                           │   │ │      │
│ │ significant history of Pancreatitis (Acute),│   │ ├──────┤
│ │ who presents with                           │   │ │  ⬇  │
│ │ complaints of abdominal pain.               │   │ ├──────┤
│ │  The onset of the abdominal pain has been   │   │ │  ⮕  │
│ │ sudden and has been                         │   │ │      │
│ │ occurring for 12 hours. The pattern of the  │   │ │      │
│ │ abdominal pain has                          │   │ │      │
│ │ been persistent. It's course has been       │   │ │      │
│ │ increasing. The abdominal                   │   │ │      │
│ │ pain is located in the right lower quadrant │   │ │      │
│ │ with radiation to the                       │   │ │      │
│ │ left flank and left lower quadrant. It is   │   │ │      │
│ │ aggravated by coughing,                     │   │ │      │
│ │ standing and walking while relief is        │   │ │      │
│ │ obtained by nothing. The                    │   │ │      │
│ │ abdominal pain is characterized as sharp    │ ⬇ │ │      │
│ │ and stabbing. The                           │   │ │      │
│ └───────────────────────────────────────────┘   │ │      │
│ ┌──┬──┐                    ┌──┐┌────┐┌─────────┐ │ │      │
│ │Cd│Mx│                    │FD││Quit││Copy to   │ │ │ 🔆  │
│ │Rx│↑ │                    └──┘└────┘│Clipboard │ │ │      │
│ └──┴──┘                              └─────────┘ │ │      │
└─────────────────────────────────────────────────┘ └──────┘
```

For the purpose of time, we will return to the first screen and show you other important features needed for a complete electronic medical record.

The next screen is the result of clicking on the REVIEW OF SYSTEM ![icon] icon from the main screen. When the selections are made, the system requests the user to respond to the Positive or Negative of the given finding. This insures that significant negatives are entered into the system since the MEDAS expert system uses the negative of the finding as well as the positive.

```
┌─────────────────────────────────────────────────┐ ┌──────┐
│                 Gastrointestinal                  │ │Reset │
│ ┌───────────────────────────────────┐           │ ├──────┤
│ │ Dysphagia                          │           │ │  📄  │
│ │ ┌───────────────────────────────┐  │           │ ├──────┤
│ │ │ Positive or Negative finding?  │  │           │ │  📑  │
│ │ │                                │  │           │ ├──────┤
│ │ │   ┌──────────┐  ┌──────────┐   │  │           │ │  ⬅  │
│ │ │   │ Positive │  │ Negative │   │  │           │ ├──────┤
│ ┌────┐ └──────────┘  └──────────┘   │  │           │ │  ⬅  │
│ │Gen │ │                            │  │           │ ├──────┤
│ ├────┤─┴────────────────────────────┘  │           │ │  ⮕  │
│ │HEENT│  Abdominal Mass                 │           │ │      │
│ ├────┬────┐ Jaundice                    │           │ │      │
│ │Neck│Heme│ Rectal Bleeding             │           │ │      │
│ ├────┼────┤ Melena                      │           │ │      │
│ │Breast│Skin│ Food Intolerance          │           │ │      │
│ ├────┼────┤                             │           │ │      │
│ │Resp│Musc│                             │           │ │      │
│ ├────┼────┤                             │           │ │      │
│ │Cardio│Neuro│                          │           │ │      │
│ ├────┼────┤                             │           │ │      │
│ │Gastro│Psych│                          │           │ │      │
│ ├────┘────┘                             │           │ │      │
│ │Male│                                  │           │ │      │
│ └────┘                         ┌To Vitals┐│         │ │      │
│ ┌──┬──┐ ┌──┐            ┌────┐ │         ││         │ │ 🔆  │
│ │Cd│Mx│ │📄│            │Quit│ └─────────┘│         │ │      │
│ │Rx│↑ │ └──┘            └────┘            │         │ │      │
│ └──┴──┘                                   │         │ │      │
└─────────────────────────────────────────────────┘ └──────┘
```

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The next screen is the result of clicking on the VITAL SIGN ⩓⩔ icon from the main screen.

VITAL SIGNS

Vitals

Supine   ### Standing

Systolic BP	120	Systolic BP		Resp Rate	22
Diastolic BP	80	Diastolic BP		Temp	102
Heart Rate	88	Heart Rate		Weight	170
				Height	

Respira

Tachypnea (rapid shallow breathing)
Hyperventilation
Bradypnea
Cheyne-Stokes breathing
Ataxic breathing
Sighing respiration
Obstructive breathing

OK

Reset

Main Menu

Quit
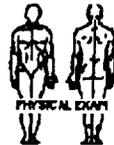
The next screen is the result of clicking on The Physical Exam **PHYSICAL EXAM** icon from the main screen.
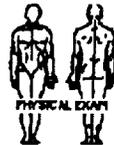
Physical Exam

	Normal	Normal Except	Not Examined		Normal	Normal Except	Not Examined		Normal	Normal Except	Not Examined
GENERAL	☐	☐	☒	❤	☐	☐	☐	RECTAL	☐	☐	☐
SKIN	☐	☐	☒		☐	☐	☐	VASC	☐	☐	☐
	☒	☐	☐		☐	☒	☐		☐	☐	☐
	☐	☐	☐	♂	☐	☐	☐		☐	☐	☐
	☐	☐	☐	♀	☐	☐	☐		☐	☐	☐

Reset

To Physical Exam Menu

Quit

There are three options for each selection: Normal, Normal Except, and Not Examined. Not Examined will print "not examined" on the report. The Normal will automatically print the significant normal on the report.

Reset
Physical Exam
Normal Normal Not
Except Examined
GENERAL
SKIN
RECTAL
VASC
To Physical Exam Menu
Quit
Cc Hx
Rx
Px

The next screen demonstrate the output by our selection. The HEET was selected as normal. Please note that the object that generates the significant normal can be modified to print more, or less information on the report.

H&P Text
Reset
FD
Quit
Copy to Clipboard
Cc Hx
Rx

+ Nausea
- Abdominal Mass

PHYSICAL EXAM

VITALS
Supine BP 120/80 Supine HR 88 Temp 102F RR 22 Wt 170

GENERAL Not Examined

SKIN Not Examined

HEENT
AT, NC, PERRLA, EOMI, Fundi w/o exudates or hemorrhages, discs sharp, Ears B/L clear, Oropharynx & sinuses clear.

To select "normal except" for the abdominal exam, click on the Abdomen ⌞χ·χ⌝ icon.

This action will start the abdominal exam program (the following screen). Each Physical Exam has its own unique options. In this exam the options are Inspection, Percussion, and Auscultation.

When selecting "Inspection" the screen controlling the Inspection objects is launched.

Inspection

Skin
Paradoxical movements
Visible peristalisis
Pulsations
Hernias
Contour
Umbilicus
Prominent veins

Reset

OK

Quit
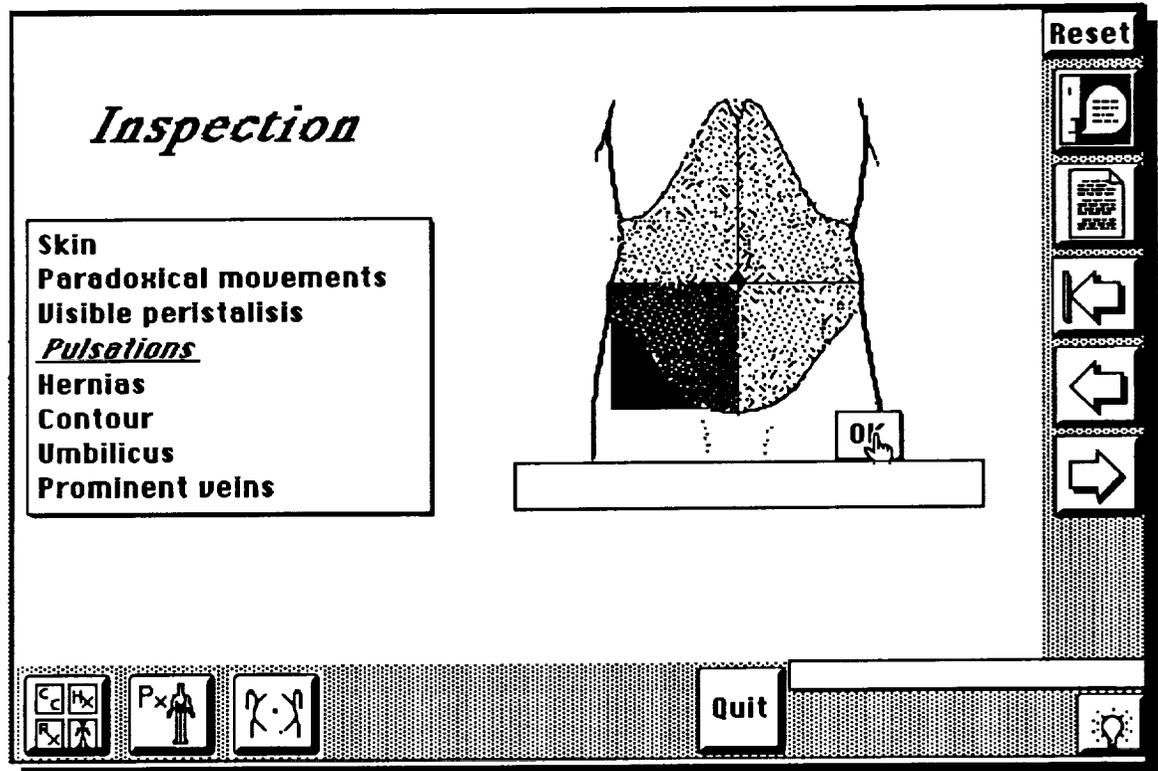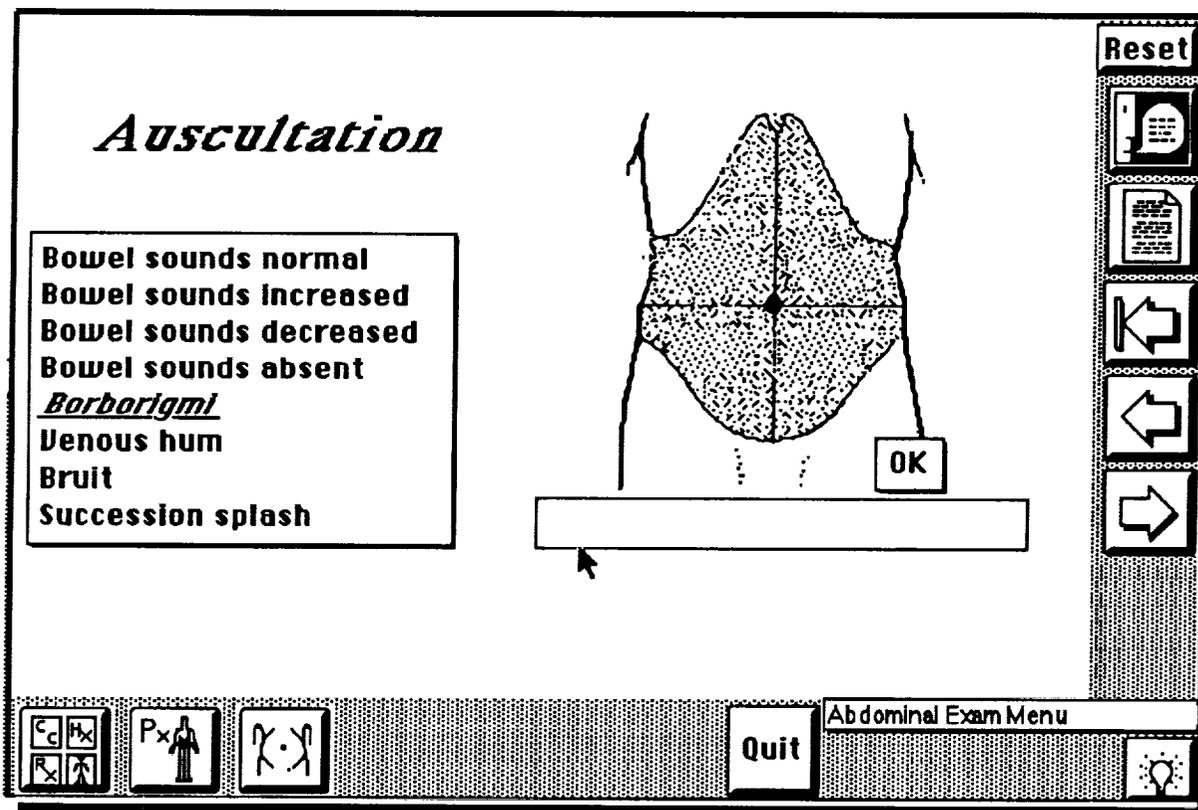
Each of the screens within the physical exam module manage 50 to 300 unique objects.

The following is an example of the "Percussion" screen.

Palpation/Percussion

Tenderness
Rebound tenderness
Rigidity (guarding)
Liver palpable
Spleen palpable
Abdominal mass palpable
Dullness to percussion
Tympanic to percussion
Shifting dullness
Fluid wave
Obturator sign
Psoas sign

Reset

Absent
Generalized
Right lower quadrant
OK

Abdominal Exam Menu

Quit
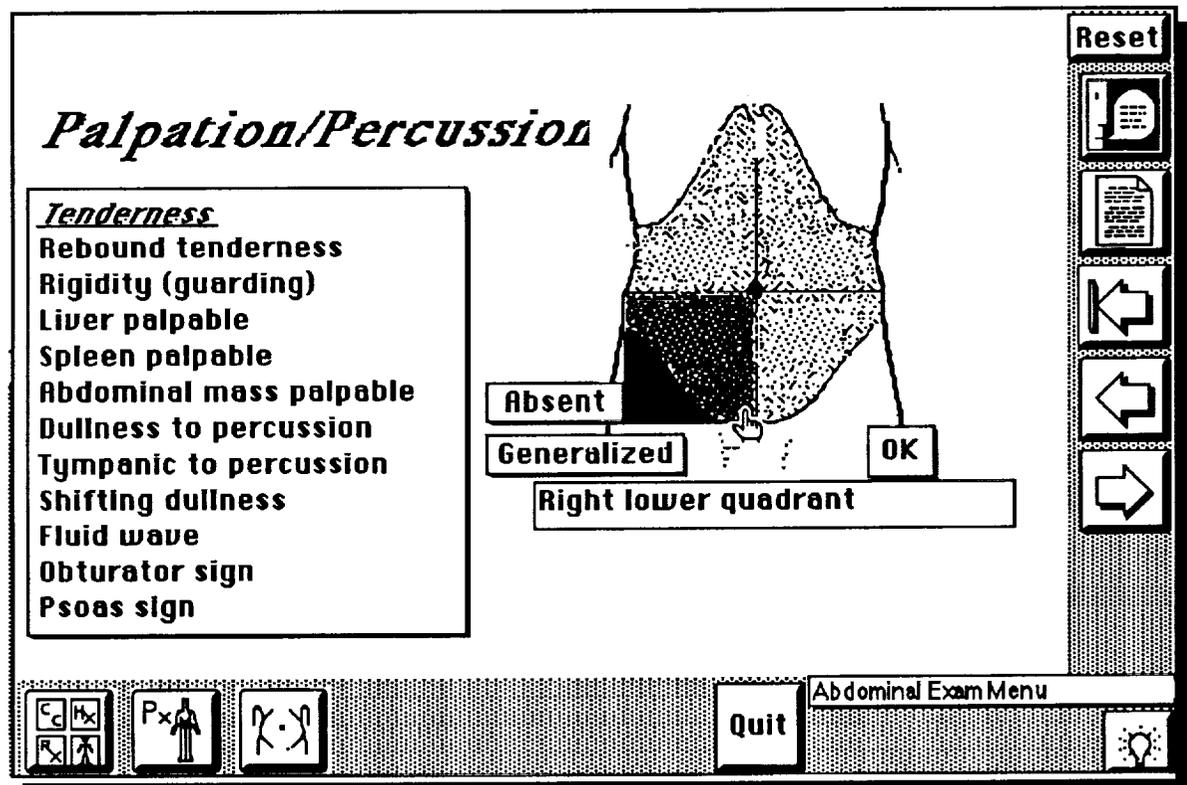
The following is an example of the "Auscultation" screen.

The Auscultation screen showing:

Auscultation

- Bowel sounds normal
- Bowel sounds increased
- Bowel sounds decreased
- Bowel sounds absent
- *Borborigmi*
- Venous hum
- Bruit
- Succession splash

OK

Abdominal Exam Menu

Quit

Reset

This next screen demonstrates the output generated by the physical exam.

H&P Text

PHYSICAL EXAM

VITALS
Supine BP 120/80   Supine HR 88   Temp 102F   RR 22   Wt 170

ABDOMEN
 Pulsations – RLQ
 Tenderness – RLQ, Absent
 Borborigmi – RLQ

Reset

FD   Quit   Copy to Clipboard

International Telemedicine/Disaster Medicine Conference
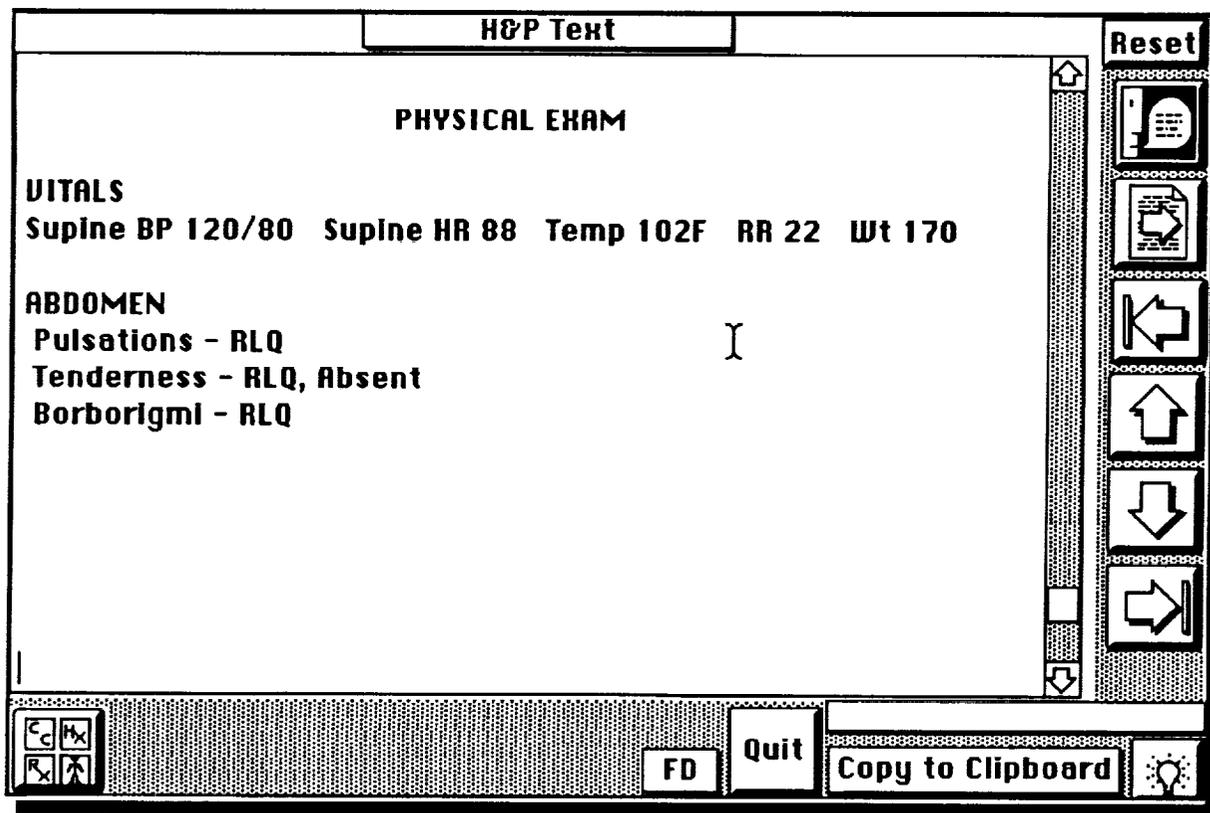
When clicking on the FD button on the lower part of the screen, the system generates the term dictionary that can be used to communicate to the expert system.

```
┌─────────┬───────────────────┐
│  back   │ Medas Dictionary  │
└─────────┴───────────────────┘
 1111443333                                                                    ⬆
 Frank
 Naeymi-Rad
 SEX.1+.male
 RACE.1+.white
 Status.2+.married
 CC.1+.Abdominal pain
 CCAC.37+.fever
 CCAC.56+.nausea
 CCAC.82+.Vomiting

 CC.1.O2+.abdominal pain onset sudden
 CC.1.D2+.abdominal pain duration hours
 CC.1.P2+.abdominal pain pattern persistent
 CC.1.C1+.abdominal pain course increasing
 CC.1.L5+.abdominal pain location right lower quadrant
 CC.1.R5+.abdominal pain radiation left flank
 CC.1.R12+.abdominal pain radiation left lower quadrant
 CC.1.A5+.abdominal pain aggravated by coughing
 CC.1.A7+.abdominal pain aggravated by standing
 CC.1.A8+.abdominal pain aggravated by walking
 CC.1.RE1+.abdominal pain relieved by nothing
 CC.1.CH2+.abdominal pain characterized as sharp
 CC.1.CH3+.abdominal pain characterized as stabbing
 CC.1.AS13+.abdominal pain associated with fever
 CC.1.AS19+.abdominal pain associated with nausea
 MEDS.97+.BENZATHINE PENICILLIN G.97
 PMHCV.38+.Cardiovascular Pulmonary Hypertension                               ⬇
```

As you can see, the system generates many terms for this very simple exam. The current system generates over 65,000 terms while the current MEDAS data dictionary has only 1,750 of these terms.

In conclusion we have demonstrated the need of an independent and complete front-end to a medical expert system.