**Appendix 1: An imperfect test grossly over estimates the prevalence of a rare disease.**

Example demonstrating the overestimation of disease prevalence that occurs when an imperfect test with sensitive and specificity of 90% is used to detect a disease with 1% prevalence.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Disease** |  |
|  |  | YES | NO | **TOTAL** |
| **Test** | POSITIVE | 9 (0.9%) | 99 (9.9%) | **\*108 (10.8%)** |
| NEGATIVE | 1 (0.1%) | 891 (89.1%) | **892 (89.2%)** |
|  | TOTAL | **10 (1%)** | **990 (99%)** | **1000 (100%)** |

In a population of 1000 individuals 10 have the disease and 990 do not. The test is 90% specific and sensitive so 99/990 will be false positive. The result is that even though 1% of the population has the diease 10.8% will test positive, grossly over estimating the true prevalence. \* Total number in population who will be test positive

**Appendix 2: Reviewer form used to judge preventability of death**

**Appendix 3:** Sensitivity analysis showing the prevalence of each latent class when the probability of preventability is divided into different numbers of intervals with equal ranges. All models have two latent classes.

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| --- | --- | --- |
|  |  | **Proportion of entire sample in each class** |
| **Model** | **Number of intervals used for the indicator variable** | **Prevalence of non-preventable death class (SE)** | **Prevalence of possibly preventable death class (SE)** |
| 1 § | Two | 0.9383 (0.0461) | 0.0617 (0.0461) |
| 2 § | Three | 0.9208 (0.0180) | 0.0792 (0.0180) |
| 3 ¶ | Four | 0.9164 (0.0163) | 0.0836 (0.0163) |
| 4 ¶ | Five | 0.9194 (0.0157) | 0.0805 (0.0157) |
| 5 ¶ | Six | 0.8539 (0.0208) | 0.1461 (0.0208) |

§ Test of absolute model fit finds no significant (P <0.05) difference between the study population and the model. ¶ No test of absolute model fit is possible. Mean probability of class membership for individuals in the class is: < 80% 🡪 ------, 80-90% 🡪 ------- , >90% 🡪 ------

**Appendix 4:** Descriptions of the “possibly preventable deaths” and the actions that may have prevented death.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Preventability ratings** | **Admitting Service** | **Age** | **Case Summary** | **Action that may have prevented the death** |
| **1** | **2** | **3** | **4** |
| 5 | 75 | 90 | 15 | INTENSIVE CARE | > 65 | A patient had a hemi-colectomy 1 month ago to resect a colon cancer. An anastomotic leak resulted in multiple abscesses. The patient was now transferred to our hospital for interventional radiology to place drains. The patient received sedatives during the procedure and had decreased LOC with hypoxemia. Narcan and flumazenil were given with no effect. The patient was then intubated and transferred to ICU. A family meeting was held and the family asked for comfort care only. | There should be standard training and procedures for the use of sedation during interventional radiology procedures. An anaesthetist should be involved when needed. |
| 70 | 20 | 38 | 75 | ONCOLOGY | > 65 | A patient with small cell lung cancer who received a first round of chemotherapy 11 days ago, presented to a peripheral hospital with febrile neutropenia, hypotension and tachycardia. They received a bolus of IV fluids and were transferred to our hospital for management. They were hypotensive on arrival (BP 84/60) but were not assessed by a physician for 6 hours after arrival. The first antibiotics were administered 6 hours after arrival. The patient continued to be hypotensive for the next 48 hours and received only small fluid boluses. 100cc/hour of NS. ICU was then consulted emergently after 48 hours. The patient was transferred to ICU and died shortly after with no further resuscitation attempted because of very poor prognosis. | Earlier antibiotics and IV fluids may have prevented death. |
| 10 | 100 | 85 | 0 | GENERAL MEDICINE | > 65 | A patient was admitted with falls, hyponatremia, 50lbs of weight loss and generalized weakness. They developed pneumonia several days into the hospitalization and were treated. They aspirated and became hypoxemic but recovered with in 24 hours. They then developed Clostridium difficile colitis and were given Flagyl. On the final day of the hospitalization they began complaining of right shoulder pain. They had rapid atrial fibrillation, hypotension decreased level of consciousness and died with in 24 hours. | The neck pain, hypotension and tachycardia should have been investigated and treated. The story is concerning for a perforated viscous. It is unlikely that proper treatment was administered considering no investigations were done. |
| 100 | 73 | 70 | 10 | GEN. SURGERY | > 65 | The patient was seen in the cancer assessment clinic after being found to have a large rectal mass with rectal bleeding. A biopsy was done via sigmoidoscopy to confirm a diagnosis of colon cancer. The patient went to surgery to have the mass resected. A "misfire" of the stapler occurred during surgery. The staple went through the rectal wall. The patient had an anastomotic leak and was brought back to OR for repair. The pathology report for the resected specimen came back showing no evidence of cancer. The patient then developed a wound infection. They then deteriorated further and goals of care changed to comfort only. | If the stapler had not misfired the patient may not have died. The surgery failed to remove the cancer even though the surgeon thought they had. |
| 80 | 0 | 20 | 75 | NEUROSURGERY | > 65 | A Patient with non-alcoholic steatohepatitis cirrhosis and severe portal hypertension who had been treated with a TIPSS procedure previously was admitted for elective carotid endarterectomy because of recurrent TIAs and severe carotid stenosis. Extensive pre-operative consultation occurred with the conclusion that they were low risk for complications. ICU was consulted urgently post-operatively for decreased level of consciousness and increased troponins. The patient was treated for SBP and a NSTEMI. The patient required intubation. Abdominal x-ray showed intestinal pneumatosis. General surgery thought the patient was too high risk to operate on and patient died shortly after. | The patient was labeled as low risk but was in fact high risk. None of the pre-operative assessments mentioned cirrhosis as a factor that increased surgical risk. Hepatic encephalopathy was not managed appropriately. |
| 100 | 50 | 50 | 100 | GENERAL MEDICINE | < 65 | The patient was admitted to hospital for hypercapnia secondary to narcotic administration and UTI. They were discharge back to their nursing home but returned to hospital 24 hours later with hypercapnic respiratory failure similar to the previous admission. The patient had received opiates at her nursing home despite not being on any opiates while in hospital, the cause for the previous admission was thought to be opiate use also. The patient was placed on non-invasive positive pressure ventilation but this was discontinued because of decreased level of consciousness made it unsafe. The patient had previously expressed they did not want intubation and so care was directed at comfort only. | Communication with the nursing home on discharge instructing them not administer opioids may have prevented the death. |
| 80 | 100 | 60 | 50 | GEN. SURGERY | > 65 | The patient was admitted with a high-grade small bowel obstruction. Multiple trials of conservative treatment were not successful. On day 8 of the admission the patient's bowels perforated. They were brought to OR emergently. Post op they were admitted to ICU for peritonitis and septic shock. They were in ICU for several weeks with ongoing sepsis and acute kidney injury requiring dialysis. Eventually family asked for comfort care only. | Earlier surgical intervention may have prevented the death. |
| 1 | 25 | 60 | 52 | INTENSIVE CARE | > 65 | The patient was seen 2 weeks ago at a different hospital and had a foley catheter inserted for urinary retention. They were sent home with the catheter. The patient presented to hospital shortly after with abdominal pain, urosepsis and shock. They were treated with IV fluids, antibiotics, vasopressors and required intubation. A CT scan revealed a ureteric stone and a stent was placed. Vancomycin was given on admission but ongoing dosing was not started until 48 hours later when urine cultures were reported as growing enterococcus. The intensive care team discussed a one-way extubation with the family. After extubation the patient did well initially but then had worsening respiratory distress and goals of care were changed to comfort only. | Investigation of the urinary retention on initial presentation with ultrasound may have revealed the cause of the obstruction. Continuation of broad-spectrum antibiotics until urine culture results were complete may have prevented the death. |
| 0 | 30 | 70 | 80 | ORTHOPEDICS | > 65 | The patient was transferred from another hospital for closed reduction of a chronic anterior shoulder dislocation. There was no documentation of assessment of pre-operative risk. The patient was requiring some supplemental oxygen for unknown reasons. Post operatively the patient had further decreased oxygen saturation, fever and elevated INR. They were diagnosed with pneumonia, UTI, and decompensated heart failure with pulmonary edema. Over the next 5 days they had decreased oxygen saturation. ICU was consulted urgently the following day for respiratory failure. The patient decided against intubation so treatment was directed at symptoms only. | The operation should have been delayed until the patient was better. The operative risk was not adequately assessed. |
| 40 | 80 | 75 | 0 | GEN. SURGERY | < 65 | The patient was admitted to ICU post resection of retroperitoneal sarcoma including nephrectomy, partial gastrectomy, splenectomy , partial diaphragm resection and adrenalectomy. On POD 9 while still in ICU the chest tube was removed. Later that day the patient complained of feeling unwell and their heart rate slowed and stopped. CPR was initiated and return of spontaneous circulation was achieved. They Patient then went to OR urgently because CXR revealed a white out of the left hemi thorax. In the OR a rupture of the thoracic aorta of unknown cause was found and repaired. The patient returned to ICU but did not recover neurologically because of anoxic brain injury sustained during the cardiac arrest. The goals of care were changed to comfort only. | Daily CXR to confirm correct placement of chest tube with no migration and CXR immediately after removal may have prevented death. It is unclear if a competent staff supervised the chest tube removal. |
| 20 | 100 | 100 | 99 | GEN. SURGERY | > 65 | The patient sustained a colon perforation during a colonoscopy and went to the operating room for a right hemi-colectomy. One year later they were admitted for elective loop ileostomy reversal. On POD 4 the patient developed pneumonia and ileus. POD 8 the patient developed AKI and an anastomotic leak. Multiple drains were placed and the patient was started on micafungin and meropenem. A one-way extubation was done on POD 30 and the patient died later that day. | Perforation caused during elective colonoscopy is rare and is possibly preventable. The elective reversal should not have been performed. The risk-benefit ratio was not adequately assessed. |
| 2 | 50 | 60 | 0 | CARDIOLOGY | > 65 | The patient was admitted with chest and hypertension. BP 180/70. He was treated with IV nitro and the chest pain resolved. On day 5 of the admission he was found to be delirious with the most likely due to acute benzodiazepine withdrawal. He was treated with low dose benzodiazepines. The following day he had a low grade fever and was found dead 4 hours later. | Patient should have had a medication reconciliation done at the time of admission. There was no investigations for causes of delirium. |
| 0 | 50 | 10 | 30 | CARDIOLOGY | > 65 | The patient was seen in clinic and was diagnosed with rapid atrial fibrillation. One week later they were seen again and still had a heart rate of 150 now with evidence of heart failure. The patient was admitted to hospital and received digoxin and diuresis. Patient required non-invasive ventilation and was started on antibiotics for a possible pneumonia. The patient continued to require non-invasive ventilation for the next 2 days. The medical team met with the family and who said that the patient would never want to be intubated. Goals were changed to comfort only and the patient died shortly after.  | No clear cause for treatment refractory atrial fibrillation was found. If this was only heart failure with pulmonary edema she should have recovered. Closer follow up may have prevented the decompensation at the second appointment.  |
| 0 | 20 | 30 | 34 | CARDIOLOGY | > 65 | The patient presented to a community hospital with an acute coronary syndrome and acute kidney injury. The patient did not respond to diuretics and received a cardiac catheterization on day 7 of admission. Renal function worsened further and the patient was transferred to our hospital. The patient developed respiratory distress and was found to have severe MR. Cardiac surgery for MR was discussed but the patient began having VT and hypotension. After a family meeting goals were changed to comfort only. | Earlier cardiac catheterization and referral to a tertiary care hospital may have prevented the death. |
| 0 | 50 | 70 | 0 | CARDIOLOGY | > 65 | The patient presented to a community hospital with STEMI, was given thrombolytic drugs and then sent to our hospital where he received urgent cardiac catheterization with 3 stents placed. Later that day the patient had recurrent chest pain and was brought back to the cath lab for thrombectomy and balloon angioplasty. The following day he had 3rd degree heart block. A transvenous pacer was put in but never turned on – unclear why not. The following day the patient had a cardiac arrest with unsuccessful resuscitation. | No definitive therapy for complete heart block was instituted. If it had been the cardiac arrest may have been prevented.  |
| 0 | 0 | 50 | 50 | CARDIOLOGY | <65 | The patient was diagnosed with infective endocarditis and aortic root abscess as a result of IV drug use. They had cardiac surgery 2 months ago because an of an enlarging aortic root abscess. They now presented to our hospital with worsening heart failure. They were continued on antibiotics. Cardiac surgery was performed on day 4 of the admission to repair the abscess and pseudoaneurisms. The patient was on bypass for 327 minutes with 157 minutes of cross clamp time. On post operative day 1 the patient was brain dead and life support was withdrawn. | Earlier surgical management may have prevented the death.  |
| 0 | 50 | 30 | 50 | CARDIOLOGY | <65 | The patient presented to hospital with left arm and ear pain. They were diagnosed with a high risk ACS based on ECG findings and elevated troponin. The patient received an urgent cardiac catheterization that revealed an aortic dissection. The patient refused surgery but it was unclear if they were competent because of a history of schizophrenia. Consent was obtained 12 hours after presentation and the patient went to the OR. On POD 2 the patient had no spontaneous movements. A CT head revealed a large acute ischemic stroke with cerebral edema. The following day a pupil was blown and the patient died shortly after. | Closer peri-op monitoring may have allowed the stroke to be detected earlier. Surgery was delayed because of difficulty getting consent from substitute decisions maker. Earlier surgery may have prevented death. |
| 6 | 0 | 45 | 90 | ORTHOPEDIC SURGERY | > 65 | A patient with alcoholic liver cirrhosis fell while getting on the bus to come to hospital because of worsening ascites. They were diagnosed with a hip fracture. The fracture was surgically repaired. On POD 23 the patient fell again in hospital fracturing the same hip. A hemi arthroplasty was performed. The following day they were drowsy and hypotensive. A 500cc fluid bolus was given but no other treatment. They were found later that afternoon with agonal breathing and profound hypotension. No action was taken and they died shortly after. | Precautions to prevent in hospital fall may have prevented the death. There was no appropriate work up or follow up for hypotension.  |
| 90 | 50 | 45 | 50 | ORTHOPEDIC SURGERY | > 65 | A patient with a chronically infected right knee arthroplasty was admitted for wash out of the joint. The joint was washed out but there was still evidence of infection. The infectious disease team recommended further wash out but it was not completed. After 4 weeks in hospital the patient developed respiratory distress and septic shock. The patient continued to worsen over the next 7 days and goals of care were changed to comfort only.  | The joint should have been washed out again as the infectious disease team recommended. |
| 5 | 50 | 30 | 0 | UROLOGY | > 65 | The patient was admitted for cystectomy and ileal conduit for bladder cancer. On POD 5 the patient was brought back to the OR for wound dehiscence. Intra-operatively they were found to have a necrotic right rectus abdominus. In the recovery room they were agitated and were told to relax. Benzodiazepines were administered. Immediately after they had a cardiac arrest. Resuscitation was unsuccessful. | Restlessness was treated symptomatically instead of looking for a cause. Necrosis of rectus abdominus was an unrecognized iatrogenic injury. |
| 0 | 40 | 35 | 5 | VASCULAR SURGERY | > 65 | The patient had a history of vascular disease and a previous aortofemoral bypass graft. They were admitted with symptoms of claudication and a CT scan showing gas around the old bipass graft. A new graft was placed and then 48 hours later the infected graft was removed. Removal of the infected graft was complicated by a duodenal tear that required repair and placement of a J-tube. The patient had a prolonged ICU stay complicated by sepsis, delirium, wound dehiscence and kidney injury requiring dialysis. 3-months into the admission the patient had recurrent signs of sepsis and a decision was made with the family not to resuscitate. | The surgical complication might have been preventable. |
| 0 | 50 | 0 | 50 | THORASIC SURGERY | > 65 | The patient had metastatic cancer with metastases to liver, bone and possibly lung. A biopsy of a lung nodule was performed to confirm the diagnosis. The patient developed a pneumothorax after the biopsy and required a pigtail catheter. The patient was sent home with the pigtail in place. 3 days later they presented with rapidly progressive dyspnea. A needle decompression was done followed by another pigtail. The patient remained in hospital and the pneumothorax recurred, requiring another pigtail. A diagnosis of cancer was confirmed and treatment was directed at comfort only.  | It is unclear why the lung biopsy was needed considering the patient already had liver and bone metastases. |
| 30 | 15 | 40 | 0 | GENERAL SURGERY | > 65 | The patient had 3 episodes of bright red blood per rectum and presented to hospital. They received 2 units of packed red cells. On day 2 they continued to have bright red blood per rectum, became hypotensive and was found unresponsive. The patient was intubated and brought to ICU where they received IV fluids and vasopressors. They continued to be hypotensive and therefore goals of care were changed to comfort only. | Closer monitoring of vital signs and more aggressive resuscitation with IV fluids early on may have prevented the death. |
| 60 | 50 | 0 | 0 | GENERAL MEDICINE | > 65 | The patient was admitted from a peripheral hospital with pan-enteritis of unclear cause. They were suicidal and cared for by psychiatry for a brief period. Then they developed septic shock with enterobacter bacteremia requiring ICU admission. The sepsis resolved and the patient was transferred back to medicine wards where they continued to have diarrhea. The patient called their nurse because they had aspirated, the respiratory therapist was called and they could not measure an oxygen saturation. There was no respiratory distress so the patient was sent for an X-ray. Upon returning to their room they had no pulse. Resuscitation with CPR was unsuccessful.  | The patient should not have left the ward when oxygen saturation could not be obtained.  |
| 0 | 75 | 0 | 50 | ORTHOPEDIC SURGERY | > 65 | The patient was admitted with leg edema and irregular heart rate. Pulmonary embolism was ruled out and the new diagnosis of atrial fibrillation was treated. The patient fell in hospital and sustained a hip fracture. The day after the surgery to fix the hip fracture the patient was hypoxemic. ICU was consulted emergently and goals of care were changed to comfort only.  | In hospital fall may have been preventable. The patient was high risk to fall in hospital. |
| 0 | 50 | 50 | 0 | GENERAL SURGERY | > 65 | The patient was admitted for a bowel perforation caused by an elective colonoscopy and polypectomy performed earlier that day. The patient went directly to the OR for a hemicolectomy. On POD 1 the patient had right hemiparesis. CT confirmed a large stroke. After discussing prognosis with the family the goals of care were changed to comfort only. The patient died shortly after. | The polypectomy may not have been necessary considering the patient’s advanced age.  |
| 75 | 50 | 30 | 0 | INTENSIVE CARE | > 65 | The patient had been discharge from hospital 2 weeks ago after being treated for pneumonia. Since the discharge they had visited ER every 4 days receiving diagnoses of delirium NYD, CHF, and most recently COPD exacerbation. The patient then had worsening dyspnea over 5 days. Their spouse found them not breathing and called paramedics. The patient received CPR, and was intubated. The patient had return of spontaneous circulation but over the next several days there was no neurologic recovery and goals were changed to comfort only.  | Respiratory failure could have been investigated and treated during the multiple ER visits.  |
| 60 | 50 | 50 | 50 | INTENSIVE CARE | < 65 | The patient presented to a peripheral hospital with weight loss, diarrhoea, dyspnea and a rash. The patient was diagnosed with HIV and had a CD4 count of 14. They were treated for PCP and fungal pneumonia. The patient developed bilateral pneumothoraxes’ requiring chest tubes, their condition worsening they were transferred to our hospital. After arrival it was discovered that PCP treatment had been an incorrect dose so treatment was started again at higher dose. The patient was also treated for candidiasis and CMV. They were not eating and no supplemental feeds were started for 3 weeks. They had decreased level of consciousness and hypotension requiring intubation. At this point anti-retrovirals were started. The patient was increasingly hypoxemic and hypotensive despite full medical management.  | Correct treatment for PCP and earlier nutrition may have prevented the death. |
| 80 | 50 | 0 | 0 | ORTHOPEDIC SURGERY | > 65 | The patient was admitted with a hip fracture after tripping and falling at home. The patient had surgical repair of the hip. On POD 8 the patient had right sided neglect and was diagnosed with a stroke. Investigations revealed atrial fibrillation as the likely cause of the stroke. The following day the patient developed melena and goals of care were changed to comfort only.  | Earlier recognition of atrial fibrillation could have resulted in anti-coagulation to prevent the stroke. Atrial fibrillation may have been present prior to surgery but it is unknown. |
| 100 | 50 | 0 | 5 | INTENSIVE CARE | < 65 | A patient with cirrhosis and ascites had a paracentesis for worsening ascites and was sent home. The following day they presented with pain at the site of the paracentesis and had a large drop in haemoglobin. They received frozen plasma and packed red cells. The following day the haemoglobin was even lower. Interventional radiology refused to embolize the bleed unless the INR was normal. The patient became hypotensive and hypoxemic. Intensive care was consulted but instead of escalating care a decision was made to focus on comfort. | Ultrasound guided paracentesis should not hit blood vessels or cause bleeding. When the patient presented to ER for the second time more aggressive management early on could have corrected the INR and normalized the haemoglobin. Interventional radiology embolization could have been pursued earlier. |
| 55 | 25 | 50 | 10 | GENERAL SURGERY | > 65 | The patient presented to ER with weakness, nausea and acute kidney injury. The symptoms resolved and they were sent home. The following day they returned with ongoing weakness, nausea and sudden onset abdominal pain. The patient was aneuric. An abdominal CT revealed acute cholecystitis. Lactate was very elevated. The patient refused ICU admission or intubation so they were treated with antibiotics alone. They died less than 24 hours after admission. | The patient should not have been sent home from ER the first time considering they had acute kidney injury and were not tolerating oral fluids. |

 CT: Computed tomography, COPD: Chronic obstructive pulmonary disease, CPR: cardio pulmonary resuscitation, CXR: Chest X-ray, ER: Emergency room, ICU: Intensive care unit, NSTEMI: Non-ST elevation myocardial infarction, OR: Operating room, PCP: pneumocystis pneumonia, POD: Post operative day, SBP: Spontaneous bacterial peritonitis, STEMI: ST elevation myocardial infarction, TIA: transient ischemic attack, TIPSS: Transjugular intrahepatic portosystemic shunt, UTI: urinary tract infection.