

Appendix 1: Repeated PDSA cycles of the Quality Improvement Study Design showing the interventions and refinements to sustain the main outcome.

| PDSA Cycle 1: Intervention- staff training and introduction of the electronic terminology coding tool | |
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| Plan | Baseline assessment of accuracy. |
| | Further engagement of stakeholders. |
| | Preparations for intervention: Permission to use the software, notification of participants, training of co-facilitators and handling of logistics. |
| | Immediate measurement of outcome and balancing measure at the training venue. |
| | Induction of the intervention in all the General hospitals in Lagos State. Mitigating contextual challenge of inadequate funds for monitoring and evaluation (M and E) of all 26 hospitals simultaneously. |
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| Do | A list of 220 diagnoses/health problems was selected from clinic attendance registers using systematic sampling technique. It was presented to a randomly selected sample of clinical coders in the ICD-10 validation study of an international primary care classification. It revealed the ICD-10 coding accuracy in the study setting (Olagundoye et al., 2018). The difficult items from this study (Appendix 2 in the supplementary file) were presented at the end-of-training coding exercise for immediate assessment of the intervention. |
| | Access and permission to use the electronic terminology coding tool granted through the representative of the developers (second author). |
| | Installation of the software unto their computers and training of co-facilitators (Doctors) on the use of the electronic terminology coding tool. |
| | Randomization of training participants (clinical coders) into two groups (manual coding and semi-automatic coding groups) at the registration desk on training day. Training activity on the usage of the electronic coding tool by a classification expert (main researcher). |

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| | <p>Immediate end-of-training coding exercise for comparison of coding accuracy between a control group that used the current coding method/materials and a test group that used the intervention.</p> |
| | <p>Software installation on the available personal computers and desktop computers in the hospitals' medical records departments.</p> |
| | <p>Commencement of continuous monitoring and evaluation a month post-induction.</p> <p>Monitoring and evaluation in phases: Division of hospitals into five geographical clusters according to the existing divisions of the State (IBILE- Ikeja, Badagry, Ikorodu, Lagos Island and Epe divisions) and random selection of a division for each phase of M and E.</p> |
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| Study | <p>A baseline ICD-10 coding accuracy of 78.7% was revealed from the validation study of an international primary care classification that entailed manual ICD-10 coding by the clinical coders in this study setting (Olagundoye et al., 2018).</p> |
| | <p>Outcome measure: Assessment of coding accuracy between the control group and the intervention group (Figure 1).</p> <p>Balancing measure: Assessment of speed of coding/time taken to complete the coding task by the two groups (Figure 2) and assessment of reliability.</p> |
| | <p>Monthly evaluation of outcome measure and process measure.</p> <p>The accuracy of codes assigned to the most recent diagnoses from a sample of 20 systematically selected patients' record folders out of the first 100 folders was assessed on a set date every month (See Figures III and IV). The sample size was based on the rule of thumb that the sample size should not be less than 5% of the population.</p> <p>Process measures included evidence of consistency with the monthly submissions of the samples of semi-automatically coded data from the hospitals to the Monitoring and Evaluation Officer as well as the evaluation of feedback forms that captured information about self-report of usage of the encoding software and coders' experiences/challenges with the new system.</p> |

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| | Observation of a consistent pattern of wrong coding of certain frequently used diagnoses affecting coding accuracy. This also implied that rote memory from years of assigning wrong codes consistently affected coding accuracy in the early post-intervention stage. See Figure III |
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| Act | The target accuracy of $\geq 95\%$ with $\leq 5\%$ error margin was adopted. |
| | Adoption of the intervention across the General hospitals on the basis of higher coding accuracy from the intervention group. |
| | Provision of feedback to the coders regarding any wrong code selections observed in the monthly M and E sheets for the previous month. |
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| PDSA Cycle 2: Refinement of the intervention following observations from PDSA Cycle 1 | |
| Plan | Ensuring continuous feedback to coders after the QI team's review of the accuracy of selected codes from the randomly selected monthly samples. |
| | Refining the intervention to address the observation of initial difficulty mastering search text conventions for medical terms with two or more words, as well as the inability of some of the clinical coders to decipher from the Thesaurus the synonyms of some medical terms commonly used by Clinicians. |
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| Do | From the monthly collections of M and E samples of coded diagnoses/health problems from the hospitals, a list of commonly used local terms and the corresponding codes for their synonyms which the non-clinician coders found difficult to recognize in the Thesaurus was compiled. The list was returned as additional feedback to the coders to be displayed on their work tables. This served to complement the ongoing intervention in achieving the aim of the QI initiative (see Appendix 3 in the supplementary file). |
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| Study | Continuous evaluation of coding accuracy across the hospitals (Figures III and IV). |

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| Act | Adoption of a list of medical terms frequently used locally and their search texts/synonyms from the Thesaurus as well as their corresponding ICD-10 codes. |
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| PDSA Cycle 3: Further refinement of the intervention to sustain the outcome. | |
| Plan | Periodic medical terminology workshops and training of new coders on the use of the electronic terminology coding tool in order to complement ongoing intervention. |
| | Enhancing communication between the coders and the QI team through courtesy phone calls to encourage feedback, to draw attention to the corrections of wrong code selections indicated by the QI team lead on the monthly M and E coding sheets for the previous month. Also, to assist with difficult codes through phone calls. |
| | Biannual courtesy visits to the hospitals to interact with the coders; evaluate the process and obtain feedback from them. In addition, seizing the opportunity to tackle difficult codes. |
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| Do | In addition to the changes introduced in PDSA cycles 1 and 2, a three-day training was conducted on ICD-10 coding and the importance of proper documentation for the coders and some in the first quarter of the year 2019. |
| | Monthly courtesy phone calls to the Heads of HIM departments in the hospitals to highlight corrections indicated on the reviewed M and E sheet and to obtain any feedback regarding the initiative. |
| | Periodic visits by a member of the QI team, to receive feedback, address questions and resolve any issues with the software. |
| Study | Continuous evaluation of monthly coding accuracy for an additional six months after the stipulated timeline to determine if the outcome was sustained (Figure III). |
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| Act | Adoption of annual training/retraining of old/new coders on medical terminology and effective usage of the software. |

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| | <p>Adoption of periodic courtesy phone calls to Heads of HIM departments for feedback purposes.</p> <p>Explanation of the Thesaurus' search text conventions for multiple worded terms to the coders at every opportunity.</p> |
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APPENDIX 2

List of wrongly coded diagnoses/health problems (Difficult items)

| | DIAGNOSES/HEALTH PROBLEMS | SELECTED WRONG CODES AND TITLES | CORRECT CODES AND TITLES |
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| 1. | Uterine fibroids | N93 (other abnormal uterine/vaginal bleeding) | D25 (leiomyoma of the uterus) |
| 2. | CA Cervix | C57.9 (malignant neoplasm of female genital organ unspecified) | C53 (CA Cervix) |
| 3. | Musculoskeletal pain | M76 (Enthesopathies of lower limb excluding foot) | M79.1 (Myalgia) |
| 4. | Neck pain | M54.9 (Dorsalgia) | M54.2 (Cervicalgia) |
| 5. | Upper Respiratory Tract Infection | J98.9 (Respiratory disorder, unspecified) | J00 - J06 (includes common cold; J00) |
| 6. | Physical Assault | Y04 (Assault by body force) | T74.1 (physical abuse) |
| 7. | Benign Prostatic Hyperplasia | N43.3 (Hydrocele unspecified) | N40 (Hyperplasia of prostate) |
| 8. | Pharyngitis | J03 (Acute tonsillitis) | J02 (Pharyngitis) |
| 9. | Arthralgia | M13 (Other arthritis) | M25.5 (Pain in joint) |
| 10. | Seizure Disorder | R56 (Convulsion NEC) | G40 (Epilepsy) |
| 11. | Septic Arthritis | M13 (Other arthritis) | M00.9 (Pyogenic arthritis unspecified) |
| 12. | Dyslipidaemia | No response | E78.5 (Hyperlipidaemia unspecified) |
| 13. | Herpes zoster in Pregnancy | B00.9 (Herpes virus infection, unspecified) | O98.5 (other viral diseases complicating pregnancy) |
| 14. | Gastroenteritis | K52.8 - Other specified non-infective gastro enteritis and colitis | A09-Gastroenteritis of presumed infectious origin |
| 15. | Epistaxis | L04.0 - Lymphadenitis | R04.0 (Epistaxis) |
| 16. | Somatization | F51 - Non-organic sleep disorder | F45.0 (Somatization disorder) |
| 17. | Reduced hearing | R94.2 - Abnormal result of pulmonary function test | H93.2 (other abnormal auditory perception) |
| 18. | Colles fracture | S42.0 - Fracture of clavicle | S52.5 (fracture of lower end of radius) |

APPENDIX 3

| | COMMON MEDICAL TERMS POSING DIFFICULTY WITH CODING ACCURACY | SYNONYMS/SEARCH TEXTS IN THE CODING SOFTWARE (THESAURUS) | ICD-10 TERMINOLOGY | ICD-10 CODE S |
|-----|--|---|--|------------------------------|
| 1. | CHRONIC HEPATITIS B | HEPATITIS; VIRUS, CHRONIC, TYPE B | CHRONIC VIRAL HEPATITIS | B18 |
| 2. | ACUTE HEPATITIS B | HEPATITIS; VIRUS, TYPE, B | ACUTE HEPATITIS B | B16 |
| 3. | VIRAL HEPATITIS | HEPATITIS; VIRUS | UNSPECIFIED VIRAL HEPATITIS | B19 |
| 4. | HEPATITIS | HEPATITIS | INFLAMMATORY LIVER DISEASE, UNSPECIFIED | K75.9 |
| 5. | ALCOHOLIC HEPATITIS | ALCOHOL;HEPATITIS | ALCOHOLIC HEPATITIS | K70.1 |
| 6. | PLEURAL EFFUSION | EFFUSION; PLEURA | PLEURAL EFFUSION, NOT ELSEWHERE CLASSIFIED | J90 |
| 7. | LEG ULCER | ULCER; LOWER LIMB | ULCER OF LOWER LIMB, NOT ELSEWHERE CLASSIFIED | L97 |
| 8. | SNAKE BITE (WITH VENOM) | SNAKE; BITE | SNAKE VENOM | T63.0 |
| 9. | SNAKE BITE (WITHOUT VENOM) | WOUND | OPEN WOUND OF UNSPECIFIED BODY REGION | T14.1 |
| 10. | VITAMIN B DEFFICIENCY | DEFICIENCY; VITAMIN B | VITAMIN B DEFFICIENCY, UNSPECIFIED | E53.9 |
| 11. | BRONCHITIS | BRONCHITIS | BRONCHITIS, NOT SPECIFIED AS ACUTE OR CHRONIC | J40 |
| 12. | ANAEMIA | HEMOGLOBIN; LOW | OTHER ANEMIAS | D64 |
| | | | ANEMIA UNSPECIFIED | D64.9 |
| 13. | RETROVIRAL DISEASE | DISEASE; RESULTING FROM HIV DISEASE | UNSPECIFIED HIV DISEASE | B24 |
| 14. | SEPSIS | GENERALIZED INFECTION | SEPTICAEMIA, UNSPECIFIED | A41.9 |
| 15. | HAEMORRHAGIC STROKE | STROKE | OTHER NON-TRAUMATIC INTRACRANIAL HEAMORRHAGE | I62 |
| | ISCHAEMIC STROKE | STROKE | CEREBRAL INFARCTION | I63 |
| 15. | CEREBROVASCULAR ACCIDENT (CVA) OR STROKE | CEREBROVASCULAR ACCIDENT | STROKE, NOT SPECIFIED AS HAEMORRHAGE OR INFARCTION | I64 |
| 16. | ERECTILE DYSFUNCTION | ERECTILE; DISORDER | FAILURE OF GENITAL RESPONSE | F52.2 |
| 17. | URINARY TRACT INFECTION(UTI) | URINARY; INFECTION | URINARY TRACT INFECTION; SITE NOT SPECIFIED | N39.0 |
| 18. | SINUSITIS | SINUSITIS | CHRONIC SINUSITIS;UNSPECIFIED | J32.9 |
| 19. | ACUTE SINUSITIS | ACUTE;SINUSITIS | ACUTE SINUSITIS; UNSPECIFIED | J01.9 |
| 20. | OTITIS MEDIA | OTITIS;MEDIA | OTITIS MEDIA;UNSPECIFIED | H66.9 |
| 21. | GOITRE | GOITER OR NONTOXIC;GOITER | NONTOXIC DIFFUSE GOITRE | E04.0 |
| 22. | TOXIC GOITRE | TOXIC;GOITER | THYROTOXICOSIS WITH DIFFUSE GOITRE | E05.0 |

| | OBSTETRICS AND GYNAECOLOGICAL PROBLEMS | SYNONYMS/SEARCH TEXTS IN THE CODING SOFTWARE (THESAURUS) | ICD-10 TERMINOLOGY | ICD-10 CODE S |
|-----|---|---|---|----------------------|
| 23. | SICKLE CELL DISORDER IN PREGNANCY | BLOOD; DISEASE, COMPLICATING PREGNANCY | OTHER DISEASES OF BLOOD AND BLOOD FORMING ORGANS AND CERTAIN DISORDERS INVOLVING THE IMMUNE MECHANISM COMPLICATING PREGNANCY, CHILDBIRTH AND THE PUERPERIUM | O99.1 |
| 24. | PUERPERAL SEPSIS | SEPSIS; PUERPERAL | PUERPERAL SEPSIS | O85 |
| 25. | PRE-ECLAMPSIA | PRE-ECLAMPSIA | PRE-ECLAMPSIA UNSPECIFIED | O14.9 |
| 26. | PIH (PREGNANCY INDUCED HYPERTENSION) | C.PREGNANCY; HYPERTENSION, PREGNANCY INDUCED | GESTATIONAL PREGNANCY INDUCED) HYPERTENSION WITHOUT SIGNIFICANT PROTEINURIA | O13 |
| 27. | FAILED ATTEMPTED ABORTION | ABORTION; ATTEMPTED | FAILED ATTEMPTED ABORTION | O07 |
| 28. | UTI IN PREGNANCY | URINARY TRACT; INFECTION, COMPLICATING PREGNANCY | UNSPECIFIED INFECTION THE URINARY TRACT IN PREGNANCY | O23 |
| 29. | FIBROID | FIBROID; UTERUS OR LEIOMYOMA; UTERUS | LEIOMYOMA OF UTERUS, UNSPECIFIED | D25 |
| 30. | FIBROID IN PREGNANCY | UTERUS; FIBROMYOMA, IN PREGNANCY OR CHILDBIRTH | MATERNAL CARE FOR TUMOR OF CORPUS UTERI | O34.1 |
| 31. | EARLY CYESIS | PREGNANCY | PREGNANCY STATE; INCIDENTAL | Z33 |
| 32. | SPONTANEOUS DELIVERY | SPONTANEOUS;DELIVERY | SINGLE SPONTANEOUS DELIVERY | O80 |
| 33. | CESAREAN SECTION | CESAREAN SECTION | DELIVERY BY CESAREAN SECTION, UNSPECIFIED | O82.9 |
| 34. | ELECTIVE CAESARIAN SECTION | CESAREAN SECTION | DELIVERY BY ELECTIVE CESAREAN SECTION | O82.0 |
| 35. | EMERGENCY CAESARIAN SECTION | CESAREAN SECTION; EMERGENCY | DELIVERY BY EMERGENCY CESAREAN SECTION | O82.1 |
| 36. | MULTIPLE DELIVERY | DELIVERY; MULTIPLE | MULTIPLE DELIVERY, UNSPECIFIED | O84.9 |
| 37. | INCOMPLETE ABORTION | ABORTION | SPONTANEOUS ABORTION, INCOMPLETE, WITHOUT COMPLICATION | O03.4 |
| 38. | COMPLETE ABORTION | ABORTION | SPONTANEOUS ABORTION, COMPLETE OR UNSPECIFIED, WITHOUT COMPLICATION | O03.9 |
| 39. | TWIN GESTATION | TWIN; PREGNANCY | TWIN PREGNANCY | O30.0 |
| 40. | MULTIPLE GESTATION | MULTIPLE;PREGNANCY | MULTIPLE GESTATION; UNSPECIFIED | O30.9 |
| 41. | RAPE | RAPE | SEXUAL ABUSE | T74.2 |
| 42. | PELVIC INFLAMMATORY DISEASE (PID) | PELVIC INFLAMMATORY DISEASE | FEMALE PELVIC INFLAMMATORY DISEASE, UNSPECIFIED | N73.9 |
| 43. | SEXUALLY TRANSMITTED INFECTION | SEXUAL; TRANSMITTED DISEASE | UNSPECIFIED SEXUALLY TRANSMITTED DISEASE | A64 |

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| 44. | OVARIAN CYST | CYST;OVARY | OTHER AND UNSPECIFIED OVARIAN CYSTS | N83.2 |
| 45. | CERVICAL INCOMPETENCE | CERVICAL; INSUFFICIENCY, IN PREGNANCY | MATERNAL CARE FOR CERVICAL INCOMPETENCE | O34.3 |
| 46. | ABNORMAL UTERINE/VAGINAL BLEEDING | HEMORRHAGE; UTERUS OR HEMORRHAGE; VAGINA | OTHER ABNORMAL UTERINE AND VAGINAL BLEEDING | N93 |
| 47. | CA CERVIX | CERVIX; CARCINOMA (click to show Neoplasm browser then type Cervix in search bar and click ICD10 box) | MALIGNANT NEOPLASM OF CERVIX UTERI, UNSPECIFIED | C53.9 |
| | PROBLEMS IN CHILDREN | SYNONYMS/SEARCH TEXTS IN THE CODING SOFTWARE (THESAURUS) | ICD-10 TERMINOLOGY | ICD-10 CODES |
| 48. | NEONATAL SEPSIS | SEPSIS; NEWBORN | BACTERIAL SEPSIS OF NEWBORN, UNSPECIFIED | P36.9 |
| 49. | PERINATAL ASPHYXIA | BIRTH; ASPHYXIA | BIRTH ASPHYXIA, UNSPECIFIED | P21.9 |
| 50. | SEVERE PERINATAL ASPHYXIA | ASPHYXIA; NEWBORN, SEVERE | SEVERE BIRTH ASPHYXIA | P21.0 |