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**Research Article**

# An Emergency Department-based system intervention to improve osteoporosis screening for older adults at high-risk of fracture

**Lesley E. Jackson[1], Rachel M. Skains[1,2], Amy Mudano[1], Norma Techarukpong[1], James S. Booth[1], Kenneth G. Saag[1], Liana Fraenkel[3], Maria I. Danila[1,2,*]**

[1]Division of Clinical Immunology and Rheumatology, University of Alabama at Birmingham, Birmingham, AL 35233, United States
[2]Geriatrics Research Education and Clinical Center, Birmingham VA Medical Center, Birmingham, AL 35233, United States
[3]Section of Rheumatology, Allergy and Immunology, Yale School of Medicine, New Haven, CT 06510, United States

*Corresponding author: Maria I. Danila, University of Alabama at Birmingham, 1720 Second Ave South, FOT 838, Birmingham, AL 35294, United States (mdanila@uabmc.edu).

## Abstract

Falls and osteoporosis are risk factors for fragility fractures. Bone mineral density (BMD) assessment is associated with better preventative osteoporosis care, but it is underutilized by those at high fracture risk. We created a novel electronic medical record (EMR) alert-driven protocol to screen patients in the Emergency Department (ED) for fracture risk and tested its feasibility and effectiveness in generating and completing referrals for outpatient BMD testing after discharge. The EMR alert was configured in 2 tertiary-care EDs and triggered by the term "fall" in the chief complaint, age (≥65 years for women, ≥70 years for men), and high fall risk (Morse score ≥ 45). The alert electronically notified ED study staff of potentially eligible patients. Participants received osteoporosis screening education and had BMD testing ordered. From November 15, 2020 to December 4, 2021, there were 2,608 EMR alerts among 2,509 patients. We identified 558 patients at high-risk of fracture who were screened for BMD testing referral. Participants were excluded for: serious illness ($N = 141$), no documented health insurance to cover BMD testing ($N = 97$), prior BMD testing/recent osteoporosis care ($N = 58$), research assistant unavailable to enroll ($N = 53$), concomitant fracture ($N = 43$), bedridden status ($N = 38$), chief complaint of fall documented in error ($N = 38$), long-term care residence ($N = 34$), participation refusal ($N = 32$), or hospitalization ($N = 3$). Of the 16 participants who had BMD testing ordered, 7 scheduled and 5 completed BMD testing. EMR alerts can help identify subpopulations who may benefit from osteoporosis screening, but there are significant barriers to identifying eligible and willing patients for screening in the ED. In our study targeting an innovative venue for osteoporosis care delivery, only about 1% of patients at high-risk of fracture scheduled BMD testing after an ED visit. Adequate resources during and after an ED visit are needed to ensure that older adults participate in preventative osteoporosis care.

**Keywords:** osteoporosis, fracture prevention, fracture risk assessment, screening, DXA

## Lay Summary

Falls and osteoporosis are risk factors for fragility fractures. Bone mineral density (BMD) assessment is associated with better preventative osteoporosis care, but it is underutilized by those at high fracture risk. We created a novel electronic medical record (EMR) alert-driven protocol to screen patients in the Emergency Department (ED) for fracture risk and tested its feasibility and effectiveness in generating and completing referrals for outpatient BMD testing after discharge. The EMR alert was configured in 2 tertiary-care EDs and was triggered among older adults that presented with a fall or were considered high fall risk. Eligible participants received osteoporosis screening education and had BMD testing ordered. From November 15, 2020 to December 4, 2021, we identified 558 patients at high-risk of fracture who were screened for BMD testing referral. Of the 16 participants who had BMD testing ordered, 7 scheduled and 5 completed BMD testing. There are significant barriers to identifying eligible and willing patients for screening in the ED. In our study targeting an innovative venue for osteoporosis care delivery, only about 1% of patients at high-risk of fracture scheduled BMD testing after an ED visit. Adequate resources during and after an ED visit are needed to ensure that older adults participate in preventative osteoporosis care.

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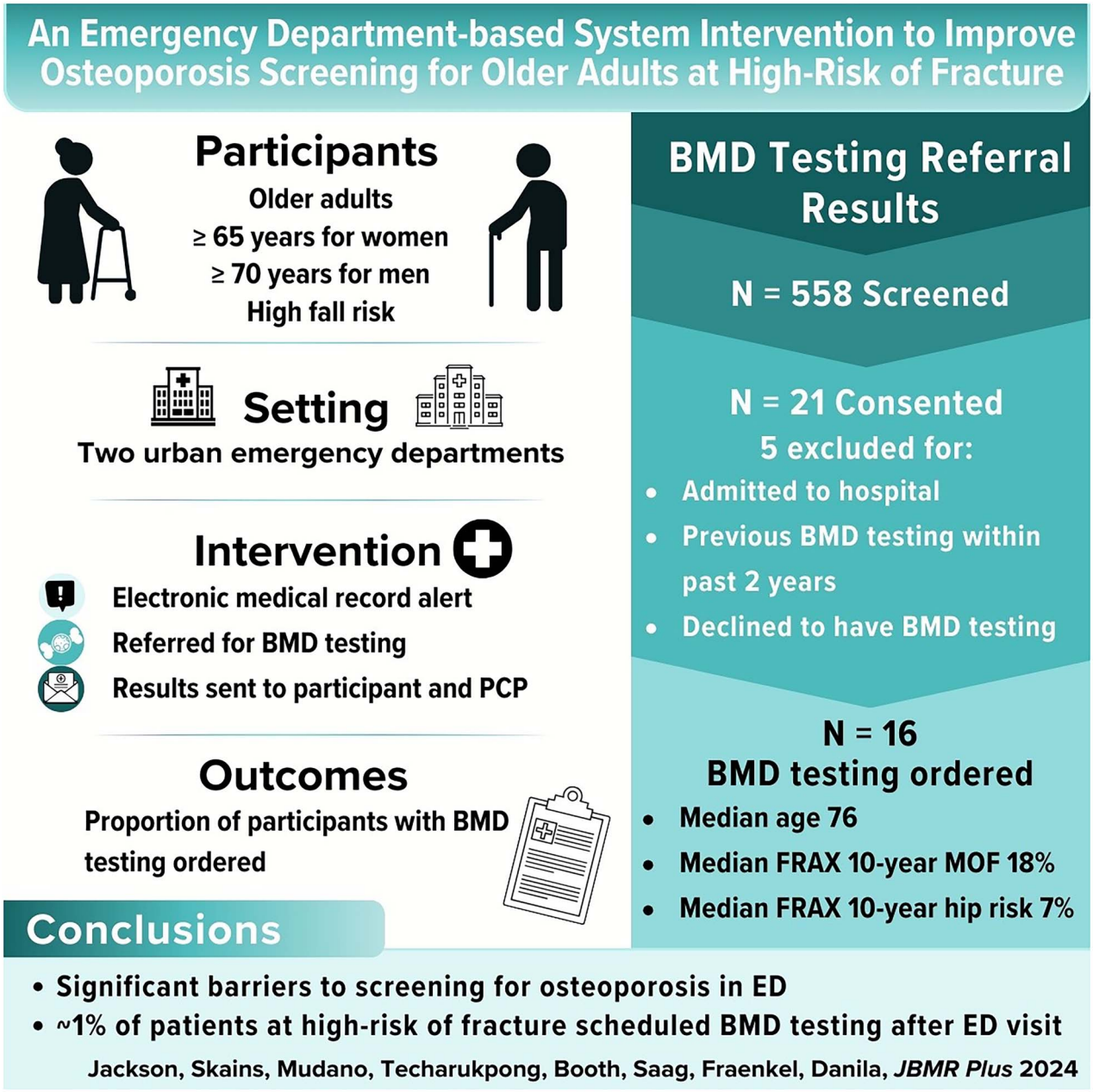
## Graphical Abstract




Falls and osteoporosis are major risk factors for fragility fractures, particularly in older adults. Fragility fractures, including hip fractures, exceed 2 million cases yearly in the United States[1] and lead to significant losses in function,[2] independence,[2] income status,[3] and quality of life.[4] Over 90% of hip fractures result from a fall, which are associated with a 30% 1-year mortality.[5,6] Community dwelling adults with one or more recent falls are more likely to experience a fracture compared to adults without falls (i.e., 2.5-fold higher odds in women and 2.3-fold higher odds in men).[7,8] Thus, fall and osteoporosis prevention are public health priorities in older people in order to prevent fragility fractures.

Older adults identified to be at high-risk of fragility fracture during fall risk screening[9–11] should undergo further assessment for modifiable risk factors, such as diagnosis and management of osteoporosis.[12] Pharmacologic treatment for osteoporosis decreases the risk of all-cause fractures by approximately 50%.[13–15] Osteoporosis screening using bone mineral density (BMD) measurement is guideline-recommended in women aged 65 years and older[16] and men aged 70 years and older.[17] Despite evidence that increased BMD testing, most commonly using dual-energy X-ray absorptiometry (DXA), is associated with greater preventative osteoporosis care, rates of screening are low.[6] Many interventions aimed at identifying and improving fragility fracture prevention in routine primary care settings have had little impact.[18–20] Therefore, novel interventions are needed in clinical settings that deliver acute ambulatory healthcare services, such as the Emergency Department (ED).

The ED offers a unique opportunity for focused efforts in fall and fracture prevention[21] in older adults for several reasons. First, fractures are more likely to occur in older adults

with both osteopenia/osteoporosis and falls,[8] and many older adults present to the ED after sustaining a fall.[22] Second, patients may be more motivated to undergo osteoporosis screening immediately after sustaining a fall when they may be concerned about a future fracture and its consequences.[22] The threat of loss of independence may lead to a "teachable moment".[22] Older adults presenting to the ED with a fall represent an enriched population that is likely to benefit from screening and treatment for osteoporosis for fragility fracture prevention. A limitation in studying these adults is deploying effective methods to identify them in real-time, an issue that we aimed to address in this study using a novel electronic medical record (EMR) alert, an approach which has been used effectively in other disease states for this purpose.[23–25]

The objective of this study was to conduct a pilot patient-directed system intervention initiated in the ED to examine the feasibility of improving uptake of screening for osteoporosis for older adults found to be at high-risk of fragility fracture. We also aimed to identify factors associated with receipt of BMD testing as a result of this intervention. To this end, we conducted a prospective, single arm interventional study using an EMR alert-driven protocol that efficiently screened patients in the ED for fracture risk and referred them for BMD testing after discharge.

## Materials and methods

### Study overview

First, using an approach we previously developed for patients presenting with gout flares in the ED,[23] we developed an EMR alert to identify patients with high-risk of fragility fracture or high-risk of fall in the ED. At our institution, upon initial triage in the ED, the chief complaint is recorded by nursing staff and entered in the EMR. Our EMR alert was triggered by the presence of certain high fall risk criteria including: age $\geq$ 65 years in women and $\geq$70 years in men, and either (1) the term "fall" in the chief complaint field of the triage note, or (2) high-risk of fall determined by a Morse fall risk score $\geq$ 45.[26,27] When these criteria were met, the EMR alert immediately notified an on-site ED research assistant or geriatric emergency nurse (if available) to assess a patient's eligibility for BMD testing. The study staff completed a fall and fracture risk checklist with patients and assessed the patients' history of BMD testing and possible past osteoporosis treatment. All participants were provided a printout with educational materials on osteoporosis that described the key role of BMD evaluation for those at greater risk of fracture (see Supplementary Material 1).

Following ED discharge, study investigators ordered BMD testing for eligible patients enrolled in the study. Patients were subsequently contacted by phone to schedule an outpatient BMD testing. To encourage follow-up for BMD testing, research staff contacted patients by a second phone call beginning approximately 2 weeks post-ED discharge to remind patients to schedule and complete BMD testing. Following BMD testing, the research team notified the patient and their primary care physician of the patients' fragility fracture risk via mailed results containing the interpretation of the BMD testing results. The study protocol was approved by the University of Alabama at Birmingham (UAB) Institutional Review Board (IRB # IRB-300005408) as a minimal risk study.

### Study setting and participants

The study was conducted from November 15, 2020 to December 4, 2021 at UAB, an urban, tertiary academic medical center with two EDs in Birmingham, AL, USA. Initially recruitment occurred at UAB – Highlands ED, which treats approximately 30,000 patients annually, and has a Level 1 Geriatric ED accreditation performing comprehensive geriatric screenings with specially-trained geriatric emergency nurses. Due to low enrollment numbers, a second recruitment site (i.e., UAB – University ED) was added 3 months later. The UAB – University ED conducts approximately 100,000 total ED visits each year and is a Level 1 trauma center. Research assistants and geriatric emergency nursing staff were available to screen patients for eligibility during typical working hours (8 a.m. to 5 p.m.). At both sites, after screening for eligibility, ED research staff explained the study purpose and provided an information sheet for those patients willing to enroll. Participants were compensated $25 for their time.

Inclusion criteria included community-dwelling older adults meeting the criteria for the EMR alert. Exclusion criteria included: (1) BMD testing or self-reported osteoporosis care, such as in an osteoporosis specialty clinic, within the previous 2 years, (2) current use of prescription medications approved for the treatment of osteoporosis, (3) no documented health insurance to cover a future BMD testing, (4) current fracture (except finger/toe), (5) bedridden status prior to ED visit, (6) residence in a long-term nursing care facility, (7) presence of cancer/serious illnesses that may limit life expectancy to <1 year (e.g., dementia), or (8) condition requiring hospital admission (this exclusion criterion was removed on January 15, 2021). Due to significant barriers to enrollment and low recruitment during the coronavirus disease 2019 (COVID-19) pandemic, the study recruitment period was extended for eight months beyond the planned end date.

### Outcomes

The primary outcome was the proportion of eligible participants who had a BMD testing ordered. Data on risk factors for fractures (e.g., age, sex, glucocorticoid use) were captured from the EMR, and/or collected from patient surveys, and were used to calculate the fracture risk assessment tool (FRAX)[28] score after the ED visit. We assessed the proportion of patients eligible for osteoporosis treatment before BMD testing based on this *FRAX* estimation without BMD measurement.

### Data collection and covariates

Once patients were enrolled in the study, data were collected using two patient surveys, including an in-person enrollment survey during the ED visit and a follow-up phone survey conducted by a research assistant after the BMD testing was complete. The surveys were administered via secure link to a Health Insurance Portability and Accountability Act (HIPAA) compliant REDCap (Nashville, TN, USA) database.[29,30]

The enrollment survey captured patient characteristics necessary for calculating FRAX, fall risk, and BMD testing eligibility. From the enrollment survey, we recorded the number of falls in past year, comorbidities, history of fracture, steroid use, and tobacco and alcohol use. Based on patients' answers to these survey questions, we categorized patients as eligible or not eligible for BMD testing.

### Transition of care and fracture risk assessment result notification

Study investigators ordered BMD testing for all enrolled participants after ED discharge. Per clinical protocols, schedulers contacted patients by phone to arrange BMD testing as an outpatient. During the follow-up phone calls, research coordinators answered questions from patients or caregivers, assessed barriers to BMD testing, and helped create action plans to overcome them. In addition, the patients received automated reminder calls 2 days before their BMD testing appointment, as per clinical protocols. Of note, BMD testing was covered by the individual patients' insurance. Following BMD testing, a board-certified rheumatologist with expertise in bone health care (MD) summarized the results of the fragility fracture assessment and mailed the report to the patient and their primary care clinician. This care coordination process was developed to help bridge current gaps in the care of older adults at high-risk for future fragility fractures.

### Statistical analysis

Survey data were exported to create master datasets in SAS (V9.4, Cary, NC, USA). We calculated measures of central tendency (sample mean or median) for continuous outcomes and patient characteristics (e.g., age). We summarized categorical variables (e.g., sex) by proportions. Using bivariate statistics for continuous and categorical data, we evaluated for the presence of sociodemographic differences in participants who were screened at high-risk for fracture by the EMR alert, including those who had BMD testing ordered and those who did not have BMD testing ordered. Among the participants who had a BMD ordered, we calculated the *FRAX* 10-year probability of major osteoporotic fracture and the *FRAX* 10-year probability of hip fracture without BMD.

### Role of funding source

This study was funded by NIH P2CHD086851, P30AR072583, T32 AR069516, and ARHQ T32 HS013852. Funders of this study were not involved in the study design, data collection, analysis, data interpretation, or writing of the manuscript.

## Results

From November 15, 2020 to December 4, 2021, there were 2,608 EMR alerts among 2,509 unique patients at our EDs. Of these, 558 patients at high-risk for fragility fracture were screened for BMD testing referral (1,951 were not screened largely due to occurring outside regular business hours) and 21 patients were consented for the study. Table 1 displays the characteristics of study participants.

Participants were excluded during screening for several reasons as shown in Figure 1. Of particular note, many patients were excluded for lack of listed health insurance (e.g., Medicare), which we required in order to ensure coverage for BMD testing. Of the 21 participants that consented to the study, 5 were excluded prior to ordering the BMD testing: 3 declined to undergo BMD testing, 1 was admitted to the hospital, and 1 was found to have had BMD testing in the previous 2 years. Of the 16 participants referred for BMD testing, 7 (44%) participants scheduled BMD testing and a total of 5 participants (31%) completed BMD testing. Despite multiple attempts, the remaining 9 (56%) participants who had BMD testing ordered could not be reached or refused to schedule BMD testing. Four of the 5 participants who completed BMD testing also completed the post-BMD testing survey.

### Characteristics of the electronic medical record alert

Timing of the EMR alert trigger varied, with the majority ($N = 1{,}495$, 60%) occurring during business hours, 8 a.m. to 5 p.m. In addition, 25% of the EMR alerts occurred on the weekends. Only 32% of EMR alerts had chief complaint of fall, while the majority of EMR alerts were triggered by the presence of high fall-risk.

### Characteristics of those with BMD testing ordered

Of the patients screened, those who had BMD testing ordered compared to those who did not have BMD testing ordered were of similar age (median [IQR] age 76 [71-85] vs 78 [73-85], $p = 0.9$), sex (women 75% vs 72%, $p = 0.4$), or race (white 47% vs 61%, $p = 0.7$). The median (IQR) Morse fall risk score[27] among those with BMD testing ordered vs not ordered was 48 (35-58) vs 50 (35-65), $p = 1.0$. For the 7 patients with BMD testing scheduled, there was a median (IQR) of 53 days (39-71) between the date of enrollment and date of scheduled BMD testing. Barriers to BMD testing included inability to reach participants by phone for care coordination and concerns by participants related to attending non-urgent healthcare visits in the setting of the contemporaneous COVID-19 pandemic (i.e., study was conducted 2020-2021), which also likely contributed to a high no-show rate for the BMD testing appointments.

Among the 16 participants who had BMD testing ordered, the *FRAX* 10-year probability of major osteoporotic fracture median (IQR) was 18% (14-24%) representing moderate risk. In this same group, the *FRAX* 10-year probability of hip fracture median (IQR) was 7% (4-12%), representing high-risk of hip fracture and higher than the threshold at which pharmacologic therapy is typically recommended. Of those with BMD testing ordered, 7 participants (44%) reported 2 or more falls in the past year, and 10 participants (63%) endorsed polypharmacy (i.e., current use of six or more medications), though no steroid use was reported. Eleven participants (69%) reported history of prior fracture. On average, participants reported overall low concern from osteoporosis (median [IQR] 2 [1-3]) and moderate risk of osteoporosis compared to others (median [IQR] 3 [2-3.5]). Only about 1% of those individuals who were identified and recommended for osteoporosis screening completed BMD testing. Of the 4 participants who underwent BMD testing and completed the follow-up survey, 3 individuals correctly reported their BMD findings, and 1 participant with normal BMD reported osteopenia.

## Discussion

In this prospective single-arm intervention study, we evaluated the feasibility of an EMR alert to identify geriatric patients who presented to the ED with a fall or were found to have a high-risk of fall and thus were at increased risk of fragility fracture. Our novel patient-directed system intervention aimed to improve uptake of screening for osteoporosis for older adults at high-risk of fragility fracture. About 1% of patients screened as having a high-risk of fragility fracture by our novel EMR-based alert were scheduled for BMD

**Table 1.** Characteristics of study participants; *N* (%) are displayed unless otherwise noted.

| | EMR alerts in unique patients *N* = 2509 | Screened patients *N* = 558 | Participants with BMD testing ordered *N* = 16 | Participants with BMD testing scheduled *N* = 7 |
|---|---|---|---|---|
| **Women ≥ 65 years** | 1,775 (71) | 400 (72) | 12 (75) | 6 (86) |
| **Men ≥ 70 years** | 734 (29) | 158 (28) | 4 (25) | 1 (14) |
| **Race** | | | | |
| Black | 881 (36) | 164 (29) | 7 (44) | 3 (43) |
| White | 1,406 (57) | 313 (56) | 7 (43.8) | 3 (43) |
| **Age, median (IQR)** | 78 (72–84) | 78 (73–85) | 76 (71–85) | 74 (70–80) |
| **Metropolitan zip code** | 2,285 (92) | 479(91) | 15 (94) | 7 (100) |
| **Insurance status** | | | | |
| Commercial | 1,535 (61) | 334 (60) | 11 (73) | 7 (100) |
| Medicare part A | 876 (35) | 191 (34) | 4 (25) | 0 (0) |
| Medicare part B | 17 (1) | 3 (1) | 0 (0) | 0 (0) |
| Medicaid | 41 (2) | 6 (1) | 0 (0) | 0 (0) |
| Champus | 17 (1) | 5 (1) | 0 (0) | 0 (0) |
| Self-pay | 23 (1) | 3 (1) | 0 (0) | 0 (0) |
| **Chief complaint of fall** | 793 (32) | 176 (32) | 8 (50) | 5 (71) |
| **Fall risk** | | | | |
| High (Morse ≥ 45) | 1,464 (62)[a] | 303 (58)[b] | 7 (44) | 1 (17) |
| Morse score, Median (IQR) | 50 (25–65) | 50 (35–65) | 48 (35–58) | 35 (25–55) |
| **Time of the alert**[c] | | | | |
| 8 a.m.–5 p.m. | 1,495 (60) | 386 (69) | 12 (75) | 6 (86) |
| 12 a.m.–7:59 a.m. | 273 (11) | 32 (6) | 0 (0) | 0 (0) |
| 5:01 p.m.–11:59 p.m. | 741 (30) | 107 (19) | 3 (19) | 1 (14) |
| **Fracture risk, median (IQR)**[d] | | | | |
| Major osteoporotic fracture | — | — | 18 (14–24) | 15 (14–22) |
| Hip fracture | — | — | 7 (4–12) | 4 (3 - 7) |

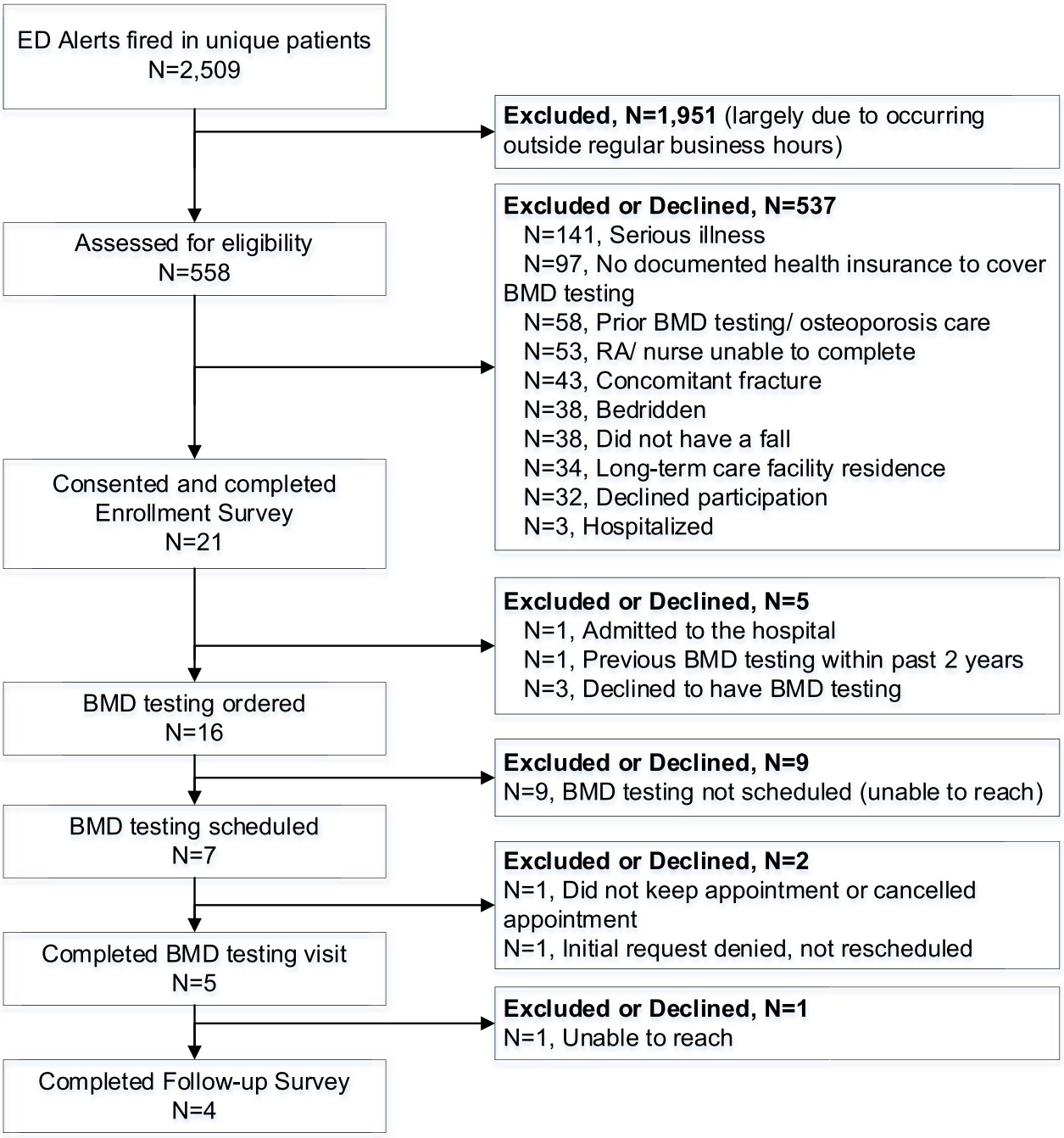
[a]Missing for 155 persons. [b]Missing for 32 persons. [c]Missing for 35 persons. [d]*FRAX* 10-year probability of major osteoporotic fracture and hip fracture were calculated without bone mineral density (BMD) inclusion. EMR, electronic medical record, IQR, interquartile range.

testing after their ED visit. Thus, there remains a large gap between the needed and received care among older patients who present to the ED with falls or have a high-risk for fall, and thus may be at a high-risk for future fractures. This study provides valuable data on the feasibility of future clinical trials focused on testing approaches in the ED to increase access to screening for osteoporosis and implementation of risk reduction strategies to prevent osteoporotic fractures.

The current standard of care relies on clinician referral to receive BMD testing. However, our previous research indicated that self-referral for BMD testing without a physician referral can successfully improve BMD testing uptake.[31] Our study built on this observation and utilized the ED as an important, but historically underutilized, setting to address osteoporosis care and prevention of future fragility fractures for those at a high-risk of falls. However, since ED fall prevention strategies alone do not appear to reduce the proportion of older adults who experience future falls,[32,33] it is important to focus efforts on osteoporosis diagnosis and treatment, which can reduce fragility fractures by 50%.[13–15] Conducting clinical research in the ED setting poses challenges to recruitment, retention, and follow-up. Prior studies have cited narrow patient eligibility criteria, EMR-related barriers to identification, and limited research support.[34,35] Moreover, since 2020, there has been a decrease in the number of patients presenting to the ED for non-COVID-19 related illnesses, including those with non-communicable diseases, such as acute coronary syndrome and injuries.[36]

Our study has several strengths. We focused on ensuring our approach was "light-touch." We developed a novel EMR-based alert to identify patients at a high-risk of fracture. While the Morse fall risk asks only two of the three questions currently recommended per practice guidelines[9–11] (i.e., it does not address worries about falling), our study was pragmatic in that the Morse fall risk was collected on all patients that presented to the ED as a hospital quality measure for fall risk assessment. Despite logistic challenges imposed by the COVID-19 pandemic, we still managed to assess 22% of patients in whom the EMR alert was triggered. Beyond the high public health impact of this study, we tested an innovative strategy to support transitions of care and patient-directed strategies to foster patient participation in fracture prevention. We will continue to incorporate our findings to test methods for improving outcomes of patients at high-risk for fracture and optimizing chronic disease care continuity in a regional underserved population.

Our study was challenged by several modifiable barriers that warrant particular note, some of which were related to the COVID-19 pandemic (e.g., low enrollment rate since patients with falls avoided ED during the study period) and have been reported for other preventative care studies in the ED.[23] A major barrier to enrollment included the EMR alert "firing" on week days before 8 a.m. or after 5 p.m. (40%) or during weekends (25%) when ED research study staff were not available to approach the patient. Recruitment improved following the expansion of sites to include UAB – University ED, such that by the study conclusion, research assistants had screened approximately two-thirds of all potential participants. Future studies focusing on preventing fragility fractures through osteoporosis care for older patients at high-risk of falls presenting to the ED may require additional staff available to enroll participants, potentially outside regular weekday business hours. Among those screened, the most common reasons for exclusion were serious illness limiting life expectancy, lack of documented health insurance, and competing demands on research assistants. We specifically excluded




BMD, bone mineral density; RA, research assistant.

**Figure 1.** Study consort diagram showing patients assessed, consented, who underwent BMD testing and completed follow up surveys. BMD, bone mineral density; RA, research assistant.

patients without documented health insurance in keeping with the goal to develop a scalable intervention, since BMD testing needed to be covered by insurance. In fact, some patients were retrospectively found to be eligible based on medical record review but were missed during initial screening. This was because health insurance status was often recorded later in the ED encounter after a patient had already been screened and excluded from the study. Thus, future studies may benefit from alternative identification and recruitment procedures, such as EMR alerts with higher specificity or broader inclusion criteria. Another limitation of this study is that we did not capture the type of fracture participants experienced prior to the beginning of the study. Specificity of the EMR alert may be improved in future iterations through automated calculation of the FRAX prior to screening by the research assistant. In addition, the inclusion criteria might be expanded to include individuals admitted to the hospital, which would allow for enrollment of individuals who may be less receptive

to preventative care intervention during acute evaluation in the ED. This may also allow inclusion of patients missed on weekends and after hours.

Among those enrolled, the primary barriers to scheduling BMD testing were the inability to reach participants and participant refusal. Interestingly, those with a BMD testing ordered had a very high estimated hip fracture risk based on the median FRAX score 7%, indicating this group would likely benefit from pharmacotherapy as treatment of osteoporosis to prevent fragility fractures, particularly hip fractures. We speculate that future studies might address participant refusal by including more focus on patient knowledge, perspectives, and education, especially through emphasis of the benefits of screening and pharmacologic therapy on fracture risk reduction. Participants that underwent BMD testing indicated very high willingness to take osteoporosis medications. However, we observed an extended duration of time between patient enrollment and the date of scheduled BMD testing (median 53 days). We hypothesize that given this delay, the need for BMD testing may no longer be top-of-mind for patients, thus influencing level of interest in scheduling this test. Future studies might focus on prioritizing more timely outpatient BMD testing following an ED visit related to a fall.

In conclusion, we developed an electronic alert and a patient-directed system intervention to address a gap in care of geriatric patients at high-risk of fracture. Despite significant barriers to enrollment, we collected valuable information that will inform future care of older patients at high-risk of fracture as well as future clinical trials addressing primary fracture prevention among those at highest risk due to falls.

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## Author contributions

Lesley E. Jackson (Formal analysis, Investigation, Methodology, Writing—original draft), Rachel M. Skains (Investigation, Methodology, Writing—review & editing), Amy Mudano (Formal analysis, Software, Writing—review & editing), Norma Techarukpong (Formal analysis, Methodology, Writing—review & editing), James S. Booth (Conceptualization, Investigation, Writing—review & editing), Kenneth G. Saag (Conceptualization, Investigation, Methodology, Supervision, Writing—review & editing), Liana Fraenkel (Conceptualization, Investigation, Methodology, Writing—review & editing), and Maria I. Danila (Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing—review & editing)

## Supplementary material

Supplementary material is available at *Journal of Bone and Mineral Research* online.

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## Conflicts of interest

None to report.

## Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Ethics approval statement

The study protocol was approved by the University of Alabama at Birmingham (UAB) Institutional Review Board (IRB # IRB-IRB-300005408).

## Patient consent statement

We received a Waiver of Authorization and Informed Consent documentation based on minimal harm. Patients were provided with information sheet on the study and the need for BMD testing (see Supplementary material).

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