

The Effect of an Electronic Medical Record Intervention on Hydroxychloroquine Prescribing Habits and Surveyed Providers' Opinions of the 2016 American Academy of Ophthalmology Guidelines in the Rheumatology and Dermatology Practices of an Academic Institution

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Abstract

Background

Retinal toxicity is a rare adverse event related to the use of hydroxychloroquine (HCQ). To address this, in 2016, the American Academy of Ophthalmology (AAO) issued guidelines recommending that HCQ not exceed 5 mg/kg/day. We analyzed HCQ prescribing habits at our institution, compared to these guidelines, and used surveys to determine the opinions on these guidelines. We then introduced, in a prospective and non-controlled study, an electronic medical record (EMR) tool to study how this intervention might affect compliance with or opinions on these guidelines.

Methods

Data were collected pre-intervention (June 2017 - January 2019) and post-intervention (March 2019 - April 2020). In January 2019 we released our EMR tool. Results were analyzed using descriptive statistics for demographic data and Fisher's exact tests for comparisons of proportions between groups.

Results

Pre-intervention, we reviewed 1,128 rheumatology charts and 282 dermatology charts. 31.0% and 39.7% respectively (32.8% combined) were prescribed HCQ > 5.0 mg/kg/day. Post-intervention, we reviewed 1,158 rheumatology charts and 106 dermatology charts. 23.1% and 26.4% respectively (23.3% combined) were prescribed HCQ > 5.0 mg/kg/day ($p < 0.00001$). Pre-intervention, we compiled 18 rheumatology surveys and 12 dermatology surveys. Post-intervention, we compiled 16 rheumatology surveys and 12 dermatology surveys. Post-intervention, fewer rheumatologists incorrectly described the AAO weight-based guidelines. Combined, there was an overall reduction but not of statistical significance ($p = 0.47$).

Conclusions

At our academic institution, there remains unfamiliarity of and hesitation to comply with the 2016 AAO guidelines. Prescribed doses often exceed what is recommended in these guidelines. An EMR tool can improve compliance with these guidelines and might improve providers' familiarity with these guidelines.

Background

Hydroxychloroquine (HCQ) is a commonly used medication in the fields of rheumatology and dermatology. This medication is an immunomodulator and is considered a disease modifying anti-rheumatic drug (DMARD). It is used to treat rheumatoid arthritis (RA), systemic lupus erythematosus (SLE), and a variety of other autoimmune skin and systemic inflammatory conditions. HCQ is

hypothesized to have a therapeutic benefit in autoimmune disease through several mechanisms. First it has an inhibitory effect on several toll-like receptors (TLRs), which disrupts co-stimulation of B-cells and antigen processing. (1-5) It also exerts a lysosomotropic effect on sub-cellular compartments affecting the acidity of endosomal compartments and thereby more broadly inhibiting normal pH-dependent processing of proteins and ligands crucial to the immune response. (6-9)

HCQ is generally well tolerated by patients and has a good safety profile. (10) However, a rare but devastating adverse event related to the use of HCQ is ophthalmologic toxicity in the form of retinopathy. If the HCQ retinopathy goes undetected, it can progress to cause vision deficits and blindness. (11, 12) This retinal toxicity is irreversible, however if diagnosed early, there is only mild and limited progression after discontinuing the medication. (13) The risk of this toxicity is cumulative and dependent on the daily dose of the medication and its duration of use. The risk of retinal toxicity in the first five years of use is low and generally under 1%. In the first 10 years this risk generally remains under 2%. But the risk increases over time, and in some studies is as high as 20% after 20 years of use. (11) As a result, rheumatologists, dermatologists, and ophthalmologists have traditionally worked together to manage patients on HCQ therapy and to mitigate these risks.

In 2016, the American Academy of Ophthalmology (AAO) issued updated guidelines for the dosing of HCQ and the ophthalmologic screening recommendations for these patients. (14) The research informing these guidelines included the above findings that the toxicity is not rare among long-term users of the medication, and that the risk for retinopathy is dependent on the daily dose in proportion to the patient's actual body weight (ABW) (as opposed to ideal body weight [IBW]). (11) These guidelines also argued that a lower risk was achieved with daily doses of HCQ < 5 mg/kg/day, based on ABW. (11) These ABW-based guidelines especially mitigated long term risk, reducing the risk at 10 and 20 years of exposure to < 2% and < 4% respectively. (14)

However, despite these guidelines, research shows that rheumatologists and dermatologists continue to prescribe daily doses of HCQ that often exceed these recommendations. (15) Given this discrepancy, we wanted to assess HCQ prescribing habits and rates of compliance with these guidelines at our academic institution. We also wanted to use survey data to better understand prescribers' opinions on these guidelines. Finally, as previous research has demonstrated improved rates of compliance with these dosing guidelines when auto-dosing functions are introduced into the electronic medical record (EMR), we conducted a prospective, non-controlled study to determine if a new tool in the EMR, could affect compliance with these guidelines. (16)

Methods

Study design and populations

Survey data and chart data were collected before (June 2017 – January 2019) and after (March 2019 – January 2020) our EMR intervention. Data was collected from the rheumatology and dermatology clinics of the University of Utah Medical Center in Salt Lake City, Utah, USA.

Chart data was taken from the EMR of outpatient clinic encounters. Through the University of Utah's enterprise data warehouse, non-identified data was queried from all rheumatology and dermatology encounters which were documented during these two time periods and in which HCQ was prescribed as part of the visit. If a patient had more than one outpatient encounter that met these criteria (with rheumatology or dermatology) during the time period, then only the most recent encounter was used. Data queried included: the most recently recorded weight (even if this was not associated with the encounter in question), recorded gender, the diagnosis linked with the HCQ prescription in the EMR, and all available prescriptions details associated with the HCQ order. No patient identifying data was collected. If no weight was on record, or if other prescription details were missing that prevented us from being able to calculate the daily dose of HCQ, then the record was removed from further analysis. Queried data assimilation and organization was conducted (RO) for subsequent statistical analysis (RO, JP).

Survey data was also collected before and after our EMR intervention. Potential features of the pre-intervention and post-intervention surveys were explored (RO, DO, CH, JP), the surveys were then written (RO) and reviewed before use (RO, DO, CH, JP). No pilot testing or cognitive interviewing was conducted. Pre-intervention surveys were anonymous paper surveys for rheumatologists (distributed and collected by an administrative assistant not associated with the study). Due to lack of proximity, the same anonymous surveys were instead e-mailed to dermatologists. Post-intervention surveys were anonymous e-mailed online surveys for both rheumatologists and dermatologists, due to ease of distribution and anonymity. Every member of our rheumatology and dermatology divisions (faculty, advanced practitioners, and fellows) were asked to participate in the surveys, both before and after our intervention. Participation was voluntary. The surveys consisted of multiple-choice or yes/no questions. Survey data analyzed included: self-reported awareness of guidelines, multiple choice questions regarding dosing recommendations of the guidelines, self-reported compliance with guidelines, and opinions regarding these guidelines (full surveys are available in the supplemental materials).

Formal institutional review board (IRB) approval at the University of Utah was obtained for medical record review and the enrollment of the providers for completion of anonymous surveys. As this was primarily a quality improvement project and was low risk, this study qualified for IRB exemption. (IRB 00132645). Consent cover letter was provided to providers for completion of anonymous surveys.

Intervention

Our intervention was the implementation of an EMR tool. This tool was a box which would appear on the screen of the EMR in any outpatient encounter when a provider proceeded to order the medication HCQ. This box would prompt the provider, when choosing the dose signature, to "click" a 5 mg/kg/day dose button. This box also simultaneously highlighted a reference to the 2016 AAO guidelines supporting this recommendation. If no weight was on record in the chart, an error message resulted. Alternative options included to "click" 400 mg daily or to enter an alternative dosing schedule manually. If a weight was on record in the chart, and the prescribed value (regardless of the option used) exceeded 5 mg/kg/day, then the provider received a dose warning message. This tool was not a "hard stop". Providers were not

required to select the recommended weight-based dose and were not required to justify their reasons for prescribing a higher dose. The EMR tool did not record data as to which of these dosing options was chosen. The only recorded variable for analysis was the final daily dose.

Measurement and outcomes

We analyzed HCQ prescribing habits of the providers and their compliance with the 2016 AAO guidelines. We also collected the providers' opinions and reasons for practice deviations from the guidelines in survey form. Finally, we evaluated whether introduction of the EMR tool correlated with any change in the rate of compliance and providers' perspectives on the guidelines.

Statistical analysis

Demographic data and ABW-based HCQ dosing prescriptions were presented as frequencies and percentages. Comparisons of proportions before and after the intervention were calculated using Fisher's exact tests. The *p*-value of < 0.05 was considered statistically significant.

Results

Pre-intervention analysis (June 2017 - January 2019)

1,128 rheumatology encounters were available for analysis (Fig. 1). Of these, 778 (68.9%) were prescribed ≤ 5 mg/kg/day and 626 (80.5%) of these were female; 277 (24.6%) were prescribed 5.1–6.5 mg/kg/day and 256 (92.4%) of these were female; 73 (6.5%) were prescribed ≥ 6.6 mg/kg/day and 70 (95.9%) of these were female. In total 350 (31.0%) rheumatology patients were prescribed an HCQ dose above the recommended limit (Table 1).

Table 1
Hydroxychloroquine Dosing Pre-Intervention

HCQ Dose (mg/kg/day)	Rheumatology, <i>n</i> (%)			Dermatology, <i>n</i> (%)		
	Female	Male	Total	Female	Male	Total
	952 (84.4)	176 (15.6)	1128	219 (77.7)	63 (22.3)	282
≤ 5	626 (80.5)	152 (19.5)	778 (69.0)	122 (71.8)	48 (28.2)	170 (60.3)
5.1–6.5	256 (92.4)	21 (7.6)	277 (24.6)	65 (83.3)	13 (16.7)	78 (27.7)
≥ 6.6	70 (95.9)	3 (4.1)	73 (6.5)	32 (94.1)	2 (5.9)	34 (12.1)

282 dermatology encounters were available for analysis (Fig. 1). Of these, 170 (60.3%) were prescribed ≤ 5 mg/kg/day and 122 (71.8%) of these were female; 78 (27.7%) were prescribed 5.1–6.5 mg/kg/day and

65 (83.3%) of these were female; 34 (12.1%) were prescribed ≥ 6.6 mg/kg/day and 32 (94.1%) of these were female. In total 112 (39.7%) dermatology patients were prescribed an HCQ dose above the recommended limit (Table 1).

Combining rheumatology and dermatology patients for whom weights were recorded, 462 (32.8%) were prescribed an HCQ dose above the recommended limit. There were significantly fewer number of patients in rheumatology encounters compared to dermatology encounters prescribed an HCQ dose above the recommended limit ($p = 0.0069$).

In rheumatology patients who received an HCQ dose ≥ 6.6 mg/kg/day, the indication was most often for RA ($n = 19$) and SLE ($n = 17$). In dermatology patients, the indications for this higher dose included lichen planus ($n = 4$), discoid lupus ($n = 2$), dermatomyositis ($n = 1$), granuloma annulare ($n = 1$), and urticaria ($n = 5$).

We compiled 18 surveys from rheumatology (18/18 = 100.0% response rate) and 12 surveys from dermatology (12/12 = 100.0% response rate) (30 surveys total). Six providers (20.0% total) [3 (16.7% of rheumatologists)/3 (25.0% of dermatologists)] incorrectly identified the recommended dose. Nine providers (30.0% total) [5 (27.8% of rheumatologists)/4 (33.3% of dermatologists)] incorrectly selected IBW rather than ABW for HCQ dose calculation. Three providers (10.0% total) [2 (11.1% of rheumatologists)/1 (8.3% of dermatologists)] claimed to not use these guidelines in their practice. Eleven providers (36.7% total) [6 (33.3% of rheumatologists)/5 (41.7% of dermatologists)] were concerned that changing a patient's dose to meet these guidelines could lead to non-adherence. Fourteen providers (46.7% total) [10 (55.6%) of rheumatologists/4 (33.3% of dermatologists)] were concerned that changing HCQ dose based on these guidelines would lead to disease flares. Seventeen providers (56.7% total) [9 (50.0% of rheumatologists)/8 (66.7% of dermatologists)] reported that if their EMR automatically calculated a weight-based dose, that this would change their practice. Twenty-four providers (80.0% total) [13 (72.2% of rheumatologists)/ 11 (91.7% of dermatologists)] felt that these guidelines accurately balance the risk of retinal toxicity with the therapeutic benefit of HCQ (Table 2).

Table 2
Survey Responses on Hydroxychloroquine Dosage and Guidelines (Pre-intervention)

Reasons	Rheumatologists, <i>n</i> (%)	Dermatologists, <i>n</i> (%)	Total, <i>n</i> (%)
	(total = 18)	(total = 12)	(total = 30)
Chose incorrect weight-based dose	3 (16.7)	3 (25.0)	6 (20.0)
Chose ideal body weight rather than actual weight	5 (27.8)	4 (33.3)	9 (30.0)
Report not using the guidelines	2 (11.1)	1 (8.3)	3 (10.0)
Express concern for non-adherence if changing the dose	6 (33.3)	5 (41.7)	11 (36.7)
Express concern for disease flare if changing the dose	10 (55.6)	4 (33.3)	14 (46.7)
Believe an EMR tool would change their practice	9 (50.0)	8 (66.7)	17 (56.7)
Agree with the guidelines	13 (72.2)	11 (91.7)	24 (80.0)

Post-intervention analysis (March 2019 - April 2020)

1,158 rheumatology encounters were available for analysis (Fig. 1). Of these, 891 (76.9%) were prescribed ≤ 5 mg/kg/day and 705 (79.1%) of these were female; 222 (19.2%) were prescribed 5.1–6.5 mg/kg/day and 197 (88.7%) of these were female; 45 (3.9%) were prescribed ≥ 6.6 mg/kg/day and 42 (93.3%) of these were female. In total 267 (23.1%) rheumatology patients were prescribed an HCQ dose above the recommended limit (Table 3).

Table 3
Hydroxychloroquine Dosing Post-Intervention

HCQ Dose (mg/kg/day)	Rheumatology, <i>n</i> (%)			Dermatology, <i>n</i> (%)		
	Female	Male	Total	Female	Male	Total
	944 (81.5)	214 (18.5)	1158	76 (71.7)	30 (28.3)	106
≤ 5	705 (79.1)	186 (20.9)	891 (76.9)	53 (67.9)	25 (32.1)	78 (73.6)
5.1–6.5	197 (88.7)	25 (11.3)	222 (19.2)	19 (86.4)	3 (13.6)	22 (20.8)
≥ 6.6	42 (93.3)	3 (6.7)	45 (3.9)	4 (66.7)	2 (33.3)	6 (5.7)

106 dermatology encounters were available for analysis (Fig. 1). Of these, 78 (73.6%) were prescribed \leq 5 mg/kg/day and 53 (67.9%) of these were female; 22 (20.8%) were prescribed 5.1–6.5 mg/kg/day and 19 (86.4%) of these were female; 6 (5.6%) were prescribed \geq 6.6 mg/kg/day and 4 (66.7%) of these were female. In total 28 (26.4%) dermatology patients were prescribed an HCQ dose above the recommended limit (Table 3).

Combining rheumatology and dermatology patients, 295 (23.3%) were prescribed an HCQ dose above the recommended limit. There was no difference in the number of patients in rheumatology encounters compared to dermatology encounters prescribed an HCQ dose above the recommended limit ($p = 0.4715$).

In rheumatology patients who received an HCQ dose \geq 6.6 mg/kg/day, the clinical indication was most often for RA ($n = 7$) and Sjogren's syndrome ($n = 4$). In dermatology patients, indications for this higher dose included unspecified dermatitis ($n = 1$), lichen planus ($n = 1$), and chilblain lupus ($n = 1$).

We compiled 16 surveys from rheumatology (16/18 = 88.9% response rate) and 12 surveys from dermatology (12/12 = 100.0% response rate) (28 total). Three (10.7% total) [0 (0.0% of rheumatologists)/3 (25.0% of dermatologists)] incorrectly identified the recommended dose as being $>$ 5.0 mg/kg/day. Nine (32.1% total) [4 (25.0% of rheumatologists)/5 (41.7% of dermatologists)] incorrectly selected IBW rather than ABW for HCQ dose calculation. Five (17.9% total) [3 (18.8% of rheumatologists)/2 (16.7% of dermatologists)] said they did not use these guidelines in their practice. Five (17.9% total) [3 (18.8% of rheumatologists)/2 (16.7% of dermatologists)] were concerned that changing a patient's dose to meet these guidelines could lead to non-adherence. Eleven (39.3% total) [7 (43.8% of rheumatologists)/4 (33.3% of dermatologists)] were concerned that changing HCQ dose based on these guidelines would lead to disease flares. Twenty-one (75.0% total) [11 (68.8% of rheumatologists)/ 10 (83.3% of dermatologists)] felt that these guidelines accurately balance the risk of retinal toxicity with the therapeutic benefit of HCQ. Ten (35.7% total) [5 (31.2% of rheumatologists)/ 5 (41.6% of dermatologists)] of prescribers (rheumatology and dermatology combined) reported being unaware of the new EMR tool entirely. Of those who reported they were aware of the EMR tool, seven (38.9%) [4 (25.0% of rheumatologists)/ 3 (25.0% of dermatologists)] reported that it "influence[d] or change[d] your prescribing practice" and 13 (72.2%) [8 (50.0% of rheumatologists)/ 5 (41.7% of dermatologists)] "find this automatic calculation feature helpful/beneficial" (Table 4).

Table 4
Survey Responses on Hydroxychloroquine Dosage and Guidelines (Post-intervention)

Reasons	Rheumatologists, <i>n</i> (%)	Dermatologists, <i>n</i> (%)	Total, <i>n</i> (%)
	(total = 16)	(total = 12)	(total = 28)
Chose incorrect weight-based dose	0 (0)	3 (25.0)	3 (10.7)
Chose ideal body weight rather than actual weight	4 (25.0)	5 (41.7)	9 (32.1)
Report not using the guidelines	3 (18.8)	2 (16.7)	5 (17.9)
Express concern for non-adherence if changing the dose	3 (18.8)	2 (16.7)	5 (17.9)
Express concern for disease flare if changing the dose	7 (43.8)	4 (33.3)	11 (39.3)
Report being unaware of the QI intervention	5 (31.3)	5 (41.7)	10 (35.7)
Agree with the guidelines	11 (68.8)	10 (83.3)	21 (75.0)
Report the QI intervention changed their practice	4 (25.0)	3 (25.0)	7 (25.0)
Report the QI intervention is helpful/beneficial	8 (50.0)	3 (25.0)	13 (46.4)

Pre-intervention versus post-intervention analysis

For rheumatologists, 350/1128 (31.0%) prescribed an HCQ dose > 5 mg/kg/day in the pre-intervention analysis and 267/1158 (23.1%) did so in the post-intervention analysis; a statistically significant decrease of 7.9% ($p = 0$). For dermatologists, 112/282 (39.7%) prescribed an HCQ dose > 5 mg/kg/day in the pre-intervention analysis and 28/106 (26.4%) did so in the post-intervention analysis; a statistically significant decrease of 13.3% ($p = .0175$). When rheumatologists and dermatologists are combined, 462/1410 (32.8%) prescribed an HCQ dose of > 5 mg/kg/day in the pre-intervention analysis and 295/1264 (23.3%) did so in the post-intervention analysis; a statistically significant decrease of 9.5% ($p < .00001$).

There were reductions in the number of rheumatologists who incorrectly identified the guideline-based weight-based dosing recommendation of HCQ after our intervention; there was no change in dermatologists. When these two groups are combined and analyzed as a whole, there was an overall reduction but not of statistical significance ($p = 0.47$). After our intervention, there were reductions in the reported concern for non-adherence, and the reported concern for a disease flare, which did not reach statistical significance. Otherwise, there were no differences in the additional surveyed questions

exploring reasons for choosing an HCQ dose and opinions on these guidelines; not when comparing before and after the intervention nor between rheumatology and dermatology (Fig. 2).

Discussion

This study reveals that there is an enduring gap between providers' intended practice and actual practice in weight-based dosing of HCQ at our academic institution. The majority of surveyed providers profess using the guidelines in their clinic practice while prescribed doses often exceed the recommended daily dose (a frequency as high as 32.8% in this study.) This could be attributed to a misunderstanding or unfamiliarity with the 2016 guidelines as 10.7–32.1% of survey respondents could not correctly identify the specifics of these dosing guidelines. A similar lack of assimilation or understanding of other aspects of these guidelines has been demonstrated elsewhere. (17) There may also be more mundane pitfalls attributable to the logistics of a busy and rushed clinical practice, not measured here, which challenge good intentions. However, survey data also suggested that this discordance may be due to providers' concern that changes in the prescribed dose of HCQ could lead to disease flares (39.3–46.7%) or may contribute to non-adherence in their patients (17.9–36.7%). Additionally, there was concern that these guidelines do not adequately balance the risk of retinal toxicity with the therapeutic benefit of HCQ (20.0–25.0%)

The fact that females were more often prescribed a higher and potentially toxic weight-based dose has been documented elsewhere and is presumably a multi-factorial phenomenon. (18) First, females are more likely to weigh less than their male counterparts. Thus females, like children and the elderly, are at risk for over-dose or toxicity when population standard dosing protocols are applied (such as the previous guidelines recommending HCQ at 400 mg daily for most patients). Alternatively, patients on higher doses may be suffering more severe disease, (although there is no way to verify this in our data) and more severe disease may persuade a provider to prescribe higher doses of HCQ, even if only temporarily, as the acute risk of the autoimmune disease outweighs the long-term risk of retinal toxicity.

An unexpected finding in this research was the number of patients who were prescribed HCQ without a contemporaneously or previously recorded weight. This suggests that even when most providers are familiar with the clinical guidelines, that lack of a recorded weight, perhaps as a systems failure in our clinical structure, is a variable which could prohibit guideline compliance in actual clinical practice. This was especially noted in the dermatology encounters where 30% of encounters were with patients for whom no weight was recorded in the EMR. Based on the findings of this research, subsequent iterations of tools in the EMR should include modification to better ensure that a weight is recorded to help guide appropriate dosing recommendations.

The majority of providers surveyed believed that the EMR tool was useful (72.2%). This proves that an EMR intervention of this nature is accepted and tolerated by providers. Previous research has suggested that EMR interventions can influence provider behaviors regarding guideline compliance. (19) We show here that our EMR intervention was associated with a decrease in the percentage of patients prescribed

HCQ doses that exceed dosing guidelines, both in the rheumatology and dermatology clinical context. This further supports that an intervention such as our EMR tool can improve compliance with these guidelines and thus improve the long-term safety of our patients.

There are weaknesses in our study. First, we have a limited sample size of providers which limits our ability to identify differences in the rate of concordance with the 2016 guidelines. Additionally, there are weaknesses inherent to our survey data. Specifically, providers were only able to confirm or deny the investigators suggested reasons for possible non-adherence with these guidelines (surveys were multiple choice). Qualitative research would be an interesting next step towards more thoroughly understanding any hesitations or barriers to adherence with these guidelines. We do not know the sensitivity and specificity of our surveys and they were not rigorously validated. Additionally, we observed changes in prescribing habits, which correlated with our EMR tool intervention; however, a causative relationship cannot be concluded from this research. The very nature of our pre-intervention survey could have increased recognition and understanding of these guidelines, rather than our EMR intervention. It is also possible that adherence to guidelines takes time and follows a “natural history” of guideline acceptance that might be reflected in this improvement over the course of one year. However, evidence shows us that active interventions are required to enhance guideline uptake and our results seem to provide another example of this finding. (20, 21) Importantly, this is not a longitudinal study but is a series cross-sectional analysis. This again limits our ability to understand any possible or suggested causality. Finally, there are logistical reasons having to do with data collection from the EMR itself. Our prescribing practices were those as defined by the prescription history. However, prescribers might communicate directly with their patients to outline a different dosing schedule or to change the dosing schedule over time. Additionally, some indications may warrant a higher dose of HCQ at diagnosis, followed by a taper after control of disease; in a cross-sectional analysis, this data would not be captured. This importantly would alter our interpretation of the data, and more importantly it is not well understood what if any increased risk for retinal toxicity this practice might incur a particular patient.

Conclusions

We believe that this research provides several important take home points and contributes significantly to our understanding of current HCQ prescribing practices and opinions on the associated AAO guidelines. First, this research highlights ongoing hesitation of some rheumatologists and dermatologists, in an academic medical center, towards adherence with the 2016 AAO recommendations for HCQ ABW-based dosing. Second, this research demonstrates ongoing unfamiliarity with the details of the recommendations therein and discrepancy between the perceived and the actual knowledge of prescribers. Despite prescribers’ declared familiarity with the 2016 recommendations regarding weight-based dosing of HCQ, prescribed HCQ doses often exceeded the recommended daily dose. Finally, our research shows that an EMR intervention, prompting safe and ABW-based dosing of HCQ, can improve adherence with these guidelines. We believe that this improvement will lead to greater patient safety over the lifetime.

Further research should be a combined effort of rheumatology, dermatology and ophthalmology to explore tools, including EMR interventions, for bridging this gap between perceived guideline use and clinical implementation. Additional interesting extensions of this research should correlate the relationship with HCQ dosing guideline adherence and the incidence of disease flares and retinal toxicity in this patient population.

List Of Abbreviations

AAO, American Academy of Ophthalmology

DMARD, disease modifying anti-rheumatic drug

EMR, electronic medical record

HCQ, hydroxychloroquine

QI, quality improvement

RA, rheumatoid arthritis

SLE, systemic lupus erythematosus

TLRs, toll-like receptors

Declarations

Ethics approval: Formal institutional review board (IRB) approval at the University of Utah was obtained for medical record review and the enrollment of the providers for completion of anonymous surveys. As this was primarily a quality improvement project and was low risk, this study qualified for IRB exemption. (IRB_00132645). Per our institutional IRB, informed consent was not required. A consent cover letter was provided to participating providers for completion of the anonymous surveys. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication: Not applicable

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: RO and JP analyzed and interpreted the chart review patient data and survey data. RO, DLO and CH performed the study design and created the surveys. RO wrote the manuscript with

editing by DLO, CH, JP; figures and tables by RO and JP. All authors read and approved the final manuscript.

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Figures

a)

b)

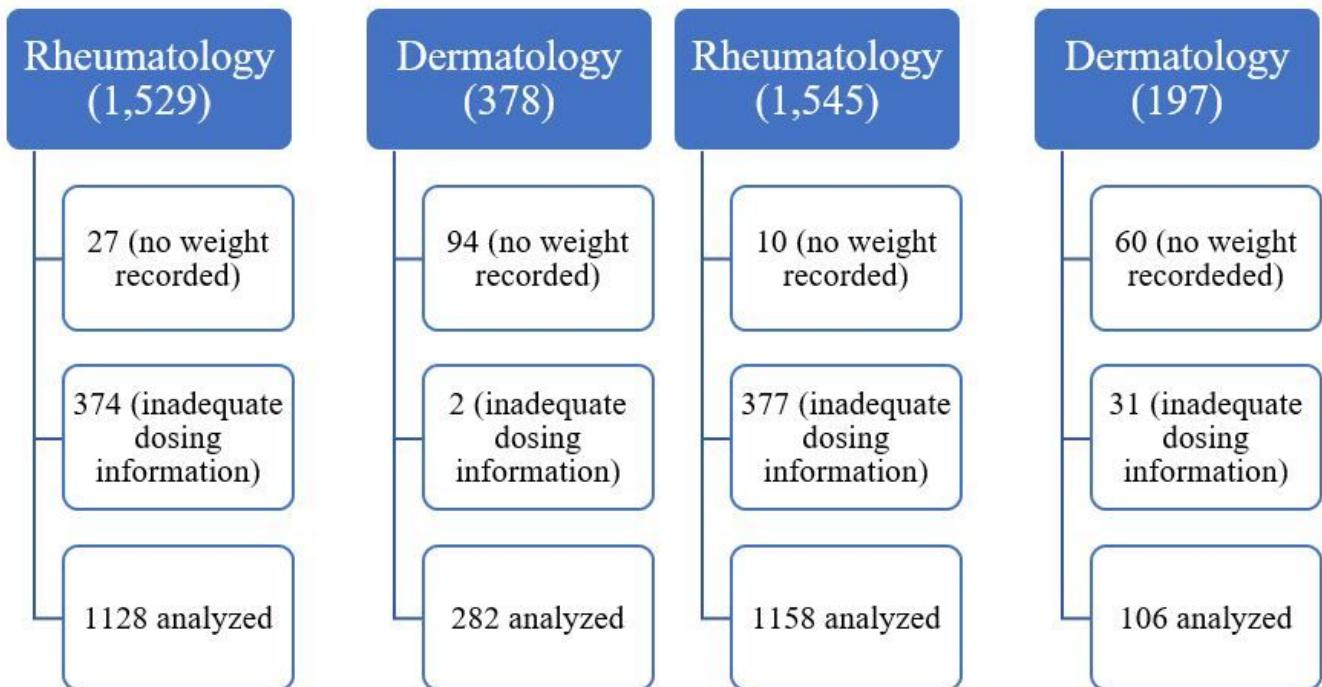


Figure 1

Pre-intervention (a) and Post-intervention (b) Chart Review

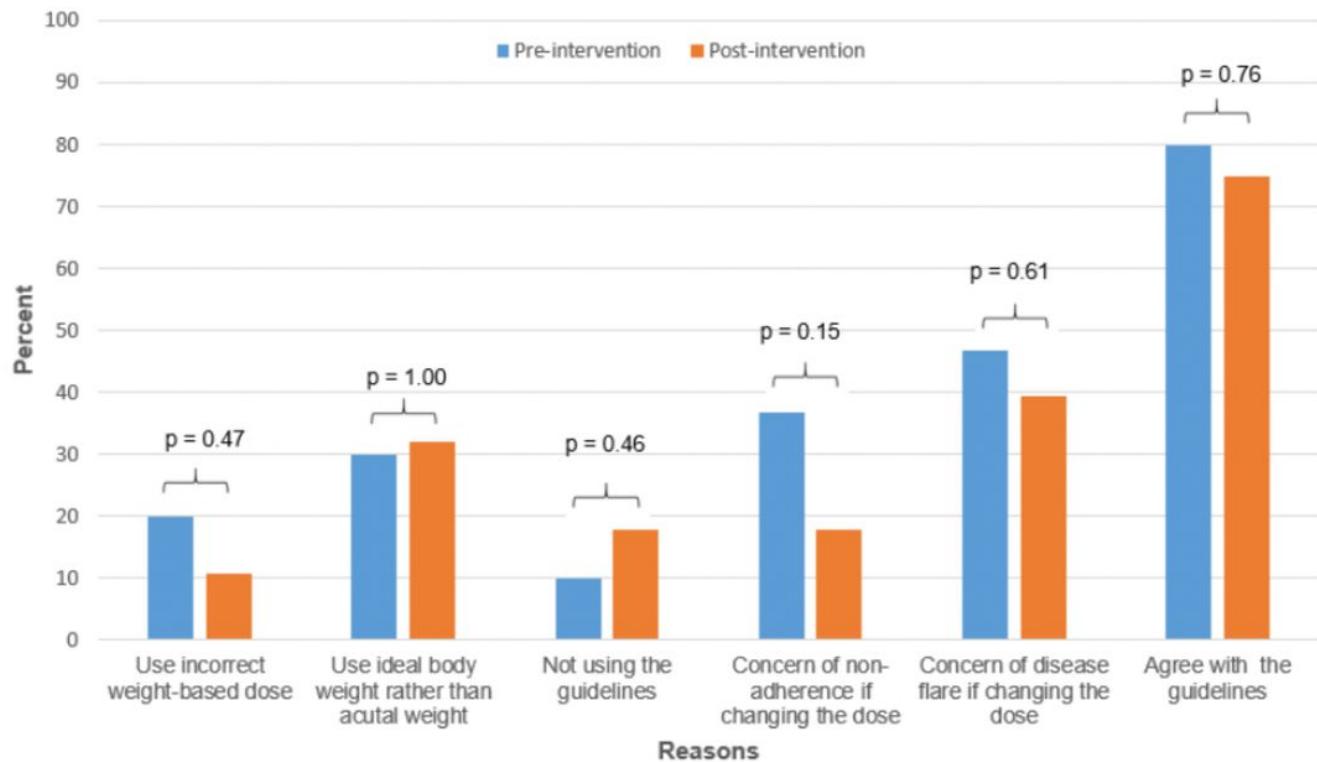


Figure 2

Reasons for Incorrect Hydroxychloroquine Dosage and Opinions on the Guidelines Before and After the Intervention

Supplementary Files

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